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PLEISTOCENE MAMMALS FROM THE SASKATCHEWAN GRAVELS
IN ALBERTA, CANADA

by

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A THESIS

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Pleistocene Mammals from the Saskatchewan Gravels in Alberta, Canada", submitted by Theodore Frederick Harold Reimchen, B.Sc., in partial fulfillment of the requirements for the degree of Master of Science.



Frontispiece: Loc. 4d, ?Mammuthus sp. Tusk
exposed in Saskatchewan gravels beneath sand
bed. Hammer is one foot in length.

ABSTRACT

This paper presents the results of a paleontologic and stratigraphic study of the Saskatchewan gravels in Alberta, Canada. These stratified fluvial sediments, composed largely of quartzose pebbles, were deposited before the advance of the Laurentide ice into central and southern Alberta. The most common fossils recovered are remains of horses, referred to Equus cf. niobrarensis Hay. Other fossils identified and described are referred to Bison sp., Camelops sp., Titanotylopus sp., Antilocapra sp., Citellus sp., and Mammuthus cf. columbi Falconer.

In North America the presently known temporal distribution of Equus niobrarensis Hay is Kansan to Wisconsin; Illinoian to Recent for Bison; Nebraskan to Wisconsin for Camelops; Late Pliocene to Yarmouth for Titanotylopus; Wisconsin to Recent for Antilocapra; Pliocene to Recent for Citellus; and ?Sangamon to Wisconsin for Mammuthus columbi Falconer.

The presence of Bison and Antilocapra in the younger (lower) levels of the Saskatchewan gravels in parts of central and southern Alberta demonstrates that these deposits may be properly assigned to the Rancholabrean Provincial Age.

The remains of Antilocapra in the low-level (youngest) Saskatchewan gravels in southeastern Alberta indicate that the maximum age for the overlying glacial drift here is Wisconsin. Similarly the presence of Bison in the low-level

Saskatchewan gravels in central Alberta indicates that the maximum possible age for overlying glacial drift in this region is Illinoian.

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The writer wishes to thank the following institutions and their staff in providing access to their collections of Pleistocene mammals: Royal Ontario Museum, Toronto; Redpath Museum, McGill University, Montreal; Field Museum of Natural History, Chicago; Museum of Paleontology, University of Michigan, Ann Arbor; American Museum of Natural History, New York; United States National Museum, Washington, D. C.; The University of Kansas Museum of Natural History, Lawrence; The University of Nebraska State Museum, Lincoln; and Drumheller District Museum Society, Drumheller, Alberta.

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The writer is sincerely grateful to his wife, Peggy, for her help in drawing the figures.

Mr. Frank Dimitrov reproduced the plates, and Miss Renate Hennig typed the final manuscript.

LIST OF ABBREVIATIONS

- AMNH American Museum of Natural History, New York.
- DDMS Drumheller District Museum Society, Drumheller,
Alberta.
- DO Private Collection, Dr. D. A. St. Onge, Geologi-
cal Survey of Canada, Ottawa, Ontario.
- MMP University of Michigan Museum of Paleontology,
Ann Arbor.
- P Private Collection, D. Polege, Camrose, Alberta.
- ROM Royal Ontario Museum, Toronto.
- TE Private Collection, Dr. T. E. Berg, Research
Council of Alberta, Edmonton, Alberta.
- UA The University of Alberta Paleontological
Collections, Edmonton, Alberta
- UAMZ The University of Alberta, Museum of Zoology,
Edmonton, Alberta.
- UNSM The University of Nebraska State Museum, Lincoln.
- USNM United States National Museum, Washington, D. C.

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INTRODUCTION

General Statement and Purpose of Study

The Saskatchewan gravels are fluviatile sediments that are composed dominantly of quartzose pebbles. Stratigraphically, the gravels lie above bedrock and below glacial drift in Alberta. Although vertebrate fossils occasionally have been recovered from these sediments, no detailed and systematic descriptions of the faunal assemblage have been previously undertaken.

The aims of this study were to collect additional fossils from the Saskatchewan gravels; to identify and describe the fossils; and to assess the significance of the sample as to the age of the Saskatchewan gravels. If the age of the youngest (lowest) levels of the Saskatchewan gravels can be ascertained in the area of study then the oldest possible age of the earliest Laurentide drift is established.

Location

All of the mammalian fossils in this study were collected in Alberta from localities south of the 56th parallel. Most of these localities were easily accessible by motor vehicle; however, since many of the outcrops are at the base of steep cutbanks along rivers, a boat proved useful. Relatively rich localities near three municipalities---Edmonton, Camrose, and Medicine Hat--- received more intensive study than the other, less fossiliferous sites (Fig. 1).

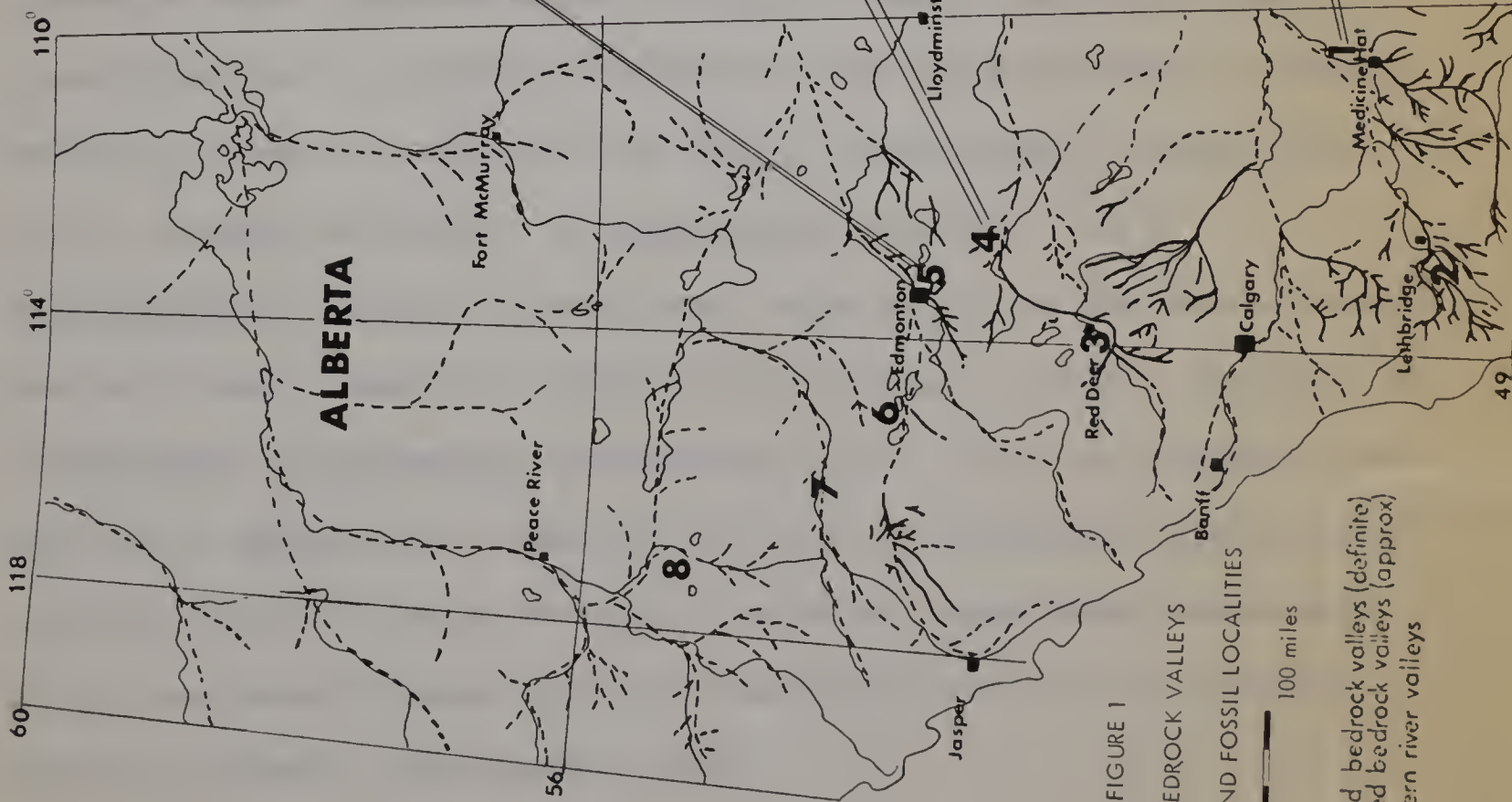
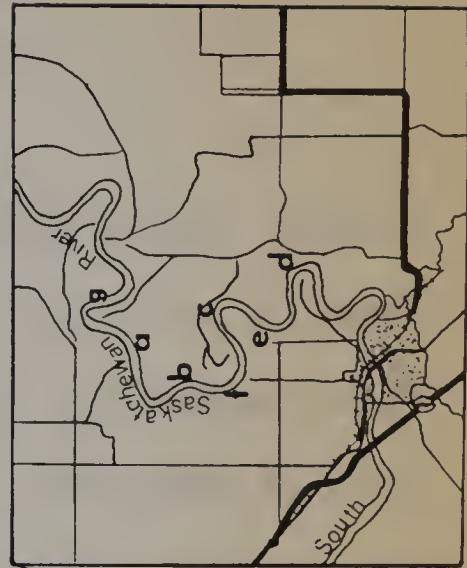
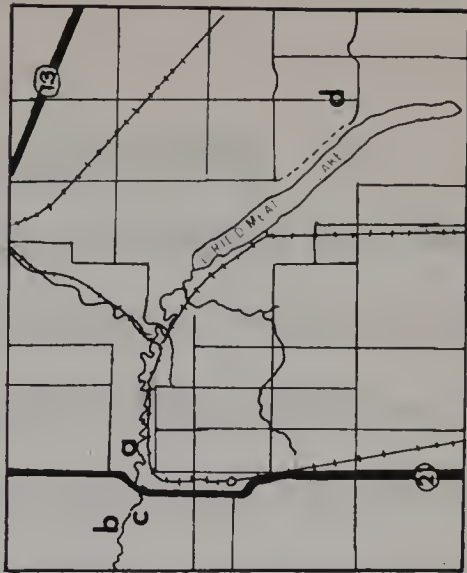


FIGURE 1
BURIED BEDROCK VALLEYS
OF ALBERTA AND FOSSIL LOCALITIES

- Buried bedrock valleys (definite)
- - - Buried bedrock valleys (approx)
- Modern river valleys

OUTCROPS OF MAJOR FOSSIL
LOCALITIES IN ALBERTA



Methods of Investigation

The surface of outcrops of the Saskatchewan gravels were prospected for fossils; where conditions seemed appropriate, dry screening was employed for recovery of small bones and teeth. A total of eight months was spent collecting fossils in the summers from 1965 to 1967.

Previous Work

At the University of Alberta are several tusks, teeth, and bones of mammoths collected from various parts of Alberta (Sternberg, 1930). Much of this material was collected years ago without stratigraphic control and is not included in the present study on that account. Rutherford (1937) records the occurrence of several specimens pertaining to Mammuthus in the ?Saskatchewan gravels near Ardley in south-central Alberta; near Edmonton, in central Alberta; and near Watino, in north-central Alberta. Remains of Equus, tentatively identified as E. scotti (Gidley), E. pacificus (Leidy), and E. midlandensis (Quinn), have been reported from the Saskatchewan gravels near Edmonton (Bayrock and Hughes, 1962). Fossils of ?Mammuthus primigenius Blumenbach and a right astragalus referred to Equus sp., identified by L. S. Russell (Chief Biologist, Royal Ontario Museum, Toronto), have been recovered from the Saskatchewan gravels near Medicine Hat in south-eastern Alberta (Westgate, 1965).

GEOLOGY OF THE SASKATCHEWAN GRAVELS

Definition and Terminology

The Saskatchewan gravels have been defined and named in several different ways, so that some confusion exists as to the sediments designated by this term. McConnell (1885) first described these sediments and named them "South Saskatchewan Gravels". Dawson and McConnell (1895) renamed them "Saskatchewan gravels". Dawson (1895) suggested that the "Saskatchewan gravels" were mainly of glaciofluvial origin and grade vertically into a boulder clay of a "pre-Laurentide" Cordilleran glaciation. In central Alberta, Rutherford (1937) preferred the term "Saskatchewan gravels and sands" for these deposits, since in places sand-sized material was the dominant constituent. He regarded the sediments as "preglacial" in the sense that they antedate glaciation from the north and east (see also Horberg, 1952; Bayrock and Hughes, 1962; Stalker, 1963; Westgate, 1965). Westgate and Bayrock (1964) indicated that some "Saskatchewan gravels and sands" in central Alberta were deposited partly in a periglacial environment before the "Classical Wisconsin". Westgate (1965, p. 87), working in southeastern Alberta, defined "Saskatchewan gravels" as "those preglacial fluviatile sediments that cover the several alluvial terraces below the Flaxville surface (Collier and Thom, 1918), and occur as channel fill in the preglacial valleys", "preglacial" being "prior to the incursion of the first Laurentide ice into the map area." The term "Saskatchewan

gravels" has priority over all others (Westgate, 1965, p. 90).

The above views are based on local criteria; when applied on a regional scale, all of the definitions are not wholly satisfactory. Because of absence of regional and detailed investigations, paucity of organic remains, multiple levels of occurrence, variability in lithology, and difficulty in ascertaining the position of the Flaxville surface, a type section for the Saskatchewan gravels has not been proposed. Consequently the term "Saskatchewan gravels" should be regarded as an informal rock-stratigraphic unit.

No attempt is made here to provide a comprehensive definition for these deposits. In the area of study (Fig. 1), the Saskatchewan gravels lie above bedrock and below the continental glacial drift. Elevations of the Saskatchewan gravels at all of the outcrops where fossils were recovered are recorded (Appendix A).

Description of the Saskatchewan Gravels

Position and Occurrence

Study of the topography of the Great Plains reveals scattered gravel-capped highlands or erosional remnants of former plains of different ages. The oldest or highest erosional remnants are Tertiary, and the youngest or lowest are Pleistocene. The deposits covering the lowest erosional remnants in southern Alberta have been termed "Saskatchewan gravels" (Dawson and McConnell, 1895). A distinct boundary between the Saskatchewan gravels and the oldest or highest Tertiary

gravels is obscure, as intermediate levels of erosion are present (see Alden, 1932, for more detailed information on erosional remnants and Fig. 2 in this report).

In the study area the Saskatchewan gravels not only occur on lower levels of wide bedrock valleys, but also on terraces several hundred feet above the floors of valleys. Because of incomplete filling by glacial drift, the major bedrock valleys appear as topographic lows through the glacial overburden. The modern rivers in the study area do not completely follow the preglacial drainage system. The rivers have incised themselves a few hundred feet into the surface of the prairie, and where the rivers cross buried bedrock valleys, outcrops of Saskatchewan gravels usually are observed. Details of this buried channel system are far from complete; only portions have been mapped (Gravenor and Bayrock, 1961; Stalker, 1961, Christiansen, 1963; Farvolden, et al. 1963; Westgate, 1965; Geiger, 1965; Jones, 1966; Carlson, 1967; Green and Laycock, 1967). Deposits equivalent to the Saskatchewan gravels have been recognized in Saskatchewan and Montana (see Westgate, 1965).

Lithology

The Saskatchewan gravels are composed of variable amounts of sand- and gravel-sized materials. Quartzose pebbles and chert generally comprise the major part of the deposits; minor amounts of basic volcanic rocks, limestone, and bedrock fragments of local derivation are also present

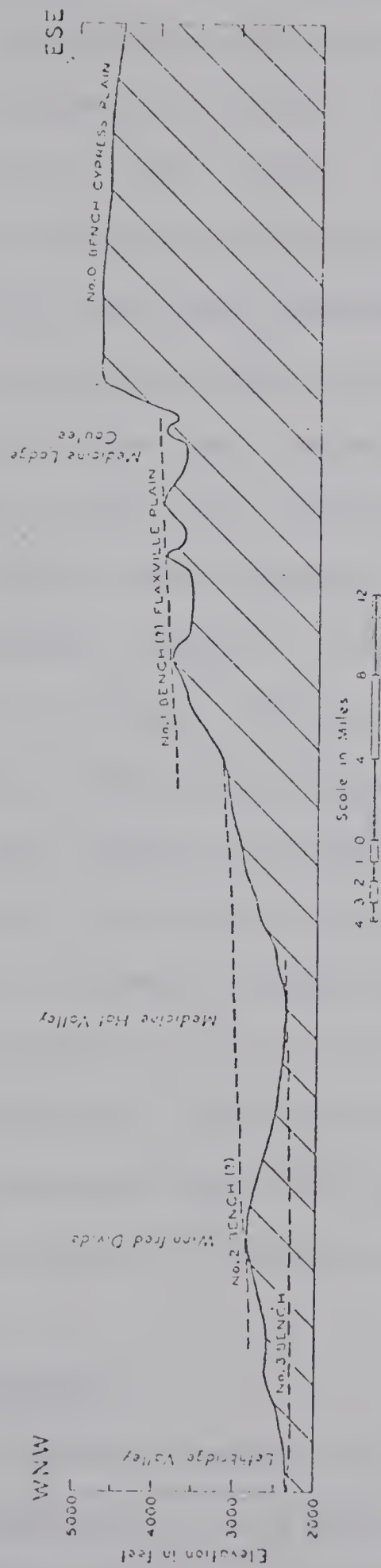


FIGURE 2. Diagrammatic sketch of Cenozoic erosional surfaces in southern Alberta and adjacent areas according to Alden (1932). After Westgate, 1968.

No. 0 Bench, Oligocene; No. 1 Bench, Miocene and Early Pliocene; No. 2 Bench, Early and Middle Pleistocene; No. 3 Bench, Late Pleistocene (Alden, 1932).

(Westgate and Bayrock, 1964). Rutherford (1937) recorded a significant variation in lithology between major bedrock valley systems. He recognized that red arkosic sandstones, abundant in the Edmonton District, are scarce in the Red Deer District, 100 miles to the south. In northern Alberta, Jones (1966) described a section of stratified sediments containing greater than thirty per cent limestone. In this area small amounts of white granitic rocks, derived from the Cordilleran region to the west, have been recognized in the Saskatchewan gravels (R. Green, 1966, oral communication). In southwestern Alberta, Wagner (1966) also records a variation in lithology between major bedrock valleys. No rocks derived from the Canadian Shield are present (Bayrock, 1965; Allong, 1967). On the Great Plains the Saskatchewan gravels can readily be differentiated from glacial gravels; the latter contain conspicuous quantities of igneous and metamorphic rocks from the Canadian Shield. In areas covered solely by Cordilleran drift, it is not easy to differentiate lithologically between the Saskatchewan gravels and glacial gravels. In this study all of the fossils recovered from the Saskatchewan gravels are from localities overlain by glacial drift of continental origin.

Sedimentary Structures

The most abundant sedimentary structures are scour and fill features, observed in both sand- and gravel-sized materials (Allong, 1967). Periglacial structures have been recognized in the Saskatchewan gravels (Westgate and Bayrock, 1964;

Westgate, 1965; Berg, 1966). Some of the gravels on terraces above the prairie level have been contorted by glacial action (L. A. Bayrock, 1965, oral communication).

Source

The source of the Saskatchewan gravels is thought to be partly from older erosional remnants of Tertiary age (McConnell, 1885; Calhoun, 1906; Alden, 1932; Rutherford, 1937) and partly the Cordilleran region to the west (Tyrrell, 1886; Dawson, 1895; Calhoun, 1906; Alden, 1932; Horberg, 1952; Bayrock and Hughes, 1962; Stalker, 1963).

Age

Divergent views have been expressed regarding the age of the Saskatchewan gravels. In southern Alberta McConnell (1885) considered "South Saskatchewan Gravels" as intermediate in age between the Miocene and Quaternary. Tyrrell (1886) suggested a post-Tertiary age but one earlier than the invasion of the continental ice. Calhoun (1906) thought that the sediments called "Saskatchewan gravels" by Dawson and McConnell (1895) ranged from late Tertiary to pre-Wisconsin. Collier and Thom (1918) regarded equivalent deposits in northern Montana as Late Pliocene or Early Pleistocene from evidence provided by a fossil tooth identified as belonging to a horse resembling the living species. Alden (1932) correlated the Saskatchewan gravels with Bench No. 3 below the Flaxville surface and considered them Late Pleistocene.

Russell and Landes (1940) tentatively assigned the Saskatchewan gravels to the Pliocene. In north-central Alberta Henderson (1959) provisionally assigned the "basal gravels" to the Early Pleistocene. A similar conclusion, based on stratigraphic position and lithology, was reached by Stalker (1963) in southern Alberta. Vertebrate fossils recovered in central Alberta and recorded by Bayrock and Hughes (1962) suggested to these authors that the Saskatchewan gravels range in age from Early Pleistocene to Sangamon or Wisconsin. Contortions within the Saskatchewan gravels indicate that some of these sediments accumulated in a periglacial climate (Westgate and Bayrock, 1964; Westgate, 1965). Radiocarbon analyses on wood found in low-level (youngest) beds of the Saskatchewan gravels do not provide dates within counting range. In north-central Alberta, at the Watino section (Loc. 7), three finite radiocarbon dates from wood found in non-glacial sediments immediately above the gravel horizon have recently been obtained (J. A. Westgate, 1967, oral communication). The finite dates recorded were: $34,900 \pm 3000/2000$ years B.P. (I-2616); $35,500 \pm 2300/1800$ years B.P. (I-2516); and $35,500 \pm 3300/2300$ years B.P. (I-2615). The conformable contact between these non-glacial stratified sediments and the underlying gravels suggests that both deposits are closely related in time. If these C-14 dates are real, therefore it follows that this particular low-level horizon of the Saskatchewan gravels is middle Wisconsin in age.

VERTEBRATE PALEONTOLOGY

Methods of Collecting

Vertebrate fossils from the Saskatchewan gravels are difficult to recognize in situ, as they are stained rusty-brown, resembling in color the enclosing gravels. Partial mineralization of some of the fossils by iron oxides has occurred but the specimens are nevertheless fragile and tend to shatter on exposure to air.

Sieving was undertaken in both sand and gravel fractions of the Saskatchewan gravels with equal success. A sieve was constructed of two interlocking boxes (1.5 feet by 4.0 feet) enclosed on three sides by walls four inches high. A 4 mm meshed screen was attached to the bottom of the upper box and a 2 mm meshed screen to the lower. Adjustable metal hose clamps were firmly attached to each corner of the lower screen for holding rods of high-tensile steel (0.5 inches by 4.0 feet). The rods were driven into the ground to a depth of not more than one foot, and the interlocking box screens were clamped to the top of the rods. Material to be processed was placed on the upper screen, and the apparatus was rocked back and forth.

Methods of Preparation

The fossils were cleaned of adhering matrix in the laboratory, and fractures were cemented by application of water insoluble glue. The fossils were then placed in a 25 gallon-capacity vacuum tank in a solution of 8 parts water,

1 part acetone, and 8 parts water-soluble glue. A pressure of 56 cm of mercury was held in the tank for an interval of five minutes; the fossils were then removed and allowed to dry. Penetration of fossils by the solution hardened the specimens and reduced their fragility.

Fossil Localities

Mammalian fossils were recovered from nineteen localities (Fig. 1). General geographic reference, legal description, and the latitude and longitude for each locality are given below:

Locality 1a: South bank of South Saskatchewan River near Medicine Hat at NE $\frac{1}{4}$ Sec. 5, Twp. 14, Rge. 5, W. 4th Mer., and NW $\frac{1}{4}$ Sec. 32, Twp. 13, Rge. 5, W. 4th Mer., ($50^{\circ} 08' 00''$ N. lat., $110^{\circ} 39' 42''$ W. long.).

Locality 1b: East bank of South Saskatchewan River near Medicine Hat at NE $\frac{1}{4}$ Sec. 24, Twp. 13, Rge. 6, W. 4th Mer., ($50^{\circ} 06' 08''$ N. lat., $110^{\circ} 41' 20''$ W. long.).

Locality 1c: Northeast bank of South Saskatchewan River near Medicine Hat at SE $\frac{1}{4}$ Sec. 20, Twp. 13, Rge. 5, W. 4th Mer., ($50^{\circ} 05' 52''$ N. lat., $110^{\circ} 38' 36''$ W. long.).

Locality 1d: Northeast bank of South Saskatchewan River near Medicine Hat at N $\frac{1}{2}$ Sec. 9, Twp. 13, Rge. 5, W. 4th Mer., ($50^{\circ} 04' 29''$ N. lat., $110^{\circ} 38' 00''$ W. long.).

Locality 1e: West bank of South Saskatchewan River near Medicine Hat at SW $\frac{1}{4}$ Sec. 17, Twp. 13, Rge. 5, W. 4th Mer., ($50^{\circ} 05' 00''$ N. lat., $110^{\circ} 39' 20''$ W. long.).

Locality 1f: South bank of South Saskatchewan River near Medicine Hat at SE $\frac{1}{4}$ Sec. 18, Twp. 13, Rge. 5, W. 4th Mer., ($50^{\circ} 05' 21''$ N. lat., $110^{\circ} 41' 12''$ W. long.).

Locality 1g: East bank of South Saskatchewan River near Medicine Hat at SE $\frac{1}{4}$ Sec. 5, Twp. 14, Rge. 5, W. 4th Mer., ($50^{\circ} 08' 16''$ N. lat., $110^{\circ} 38' 28''$ W. long.).

Locality 2: East bank of Oldman River above Lethbridge Power Plant at NE $\frac{1}{4}$ Sec. 36, Twp. 8, Rge. 22, W. 4th Mer., ($49^{\circ} 41' 42''$ N. lat., $112^{\circ} 51' 30''$ W. long.).

Locality 3: North bank of Red Deer River bordering Municipal Golf Course at S $\frac{1}{2}$ Sec. 18, Twp. 38, Rge. 27, W. 4th Mer., ($52^{\circ} 16' 09''$ N. lat., $113^{\circ} 50' 53''$ W. long.).

Locality 4a: North bank of Battle River at NE $\frac{1}{4}$ Sec. 9, Twp. 46, Rge. 21, W. 4th Mer., ($52^{\circ} 57' 32''$ N. lat., $112^{\circ} 58' 56''$ W. long.).

Locality 4b: North bank of Battle River at NE $\frac{1}{4}$ Sec. 9, Twp. 46, Rge. 21, W. 4th Mer., ($52^{\circ} 57' 32''$ N. lat., $112^{\circ} 58' 56''$ W. long.).

Locality 4c: South bank of Battle River at SE $\frac{1}{4}$ Sec. 9, and SW $\frac{1}{4}$ Sec. 10, Twp. 46, Rge. 21, W. 4th Mer., ($52^{\circ} 56' 55''$ N. lat., $112^{\circ} 58' 34''$ W. long.).

Locality 4d: Top of Driedmeat Hill at NW $\frac{1}{4}$ Sec. 17, Twp. 45, Rge. 19, W. 4th Mer., ($52^{\circ} 52' 47''$ N. lat., $112^{\circ} 43' 56''$ W. long.).

Locality 5a: North bank of North Saskatchewan River near Edmonton at NW $\frac{1}{4}$ Sec. 16, Twp. 52, Rge. 25, W. 4th Mer., ($53^{\circ} 29' 22''$ N. lat., $113^{\circ} 36' 58''$ W. long.).

Locality 5b: East bank of North Saskatchewan River near Edmonton at SW $\frac{1}{4}$ Sec. 2, Twp. 52, Rge. 25, W. 4th Mer., ($53^{\circ} 29' 15''$ N. lat., $113^{\circ} 19' 24''$ W. long.).

Locality 5c: One-half mile northwest of Clover Bar Post Office at S $\frac{1}{2}$ Sec. 16, Twp. 53, Rge. 23, W. 4th Mer., ($53^{\circ} 34' 28''$ N. lat., $113^{\circ} 19' 24''$ W. long.).

Locality 6: Two and one-half miles north of Wabamum town site at SE $\frac{1}{4}$ Sec. 23, Twp. 53, Rge. 4, W. 5th Mer., ($53^{\circ} 35' 25''$ N. lat., $114^{\circ} 28' 13''$ S. long.).

Locality 7: East bank of Athabasca River at NW $\frac{1}{4}$ Sec. 23, Twp. 61, Rge. 7, W. 5th Mer., ($54^{\circ} 17' 45''$ N. lat., $114^{\circ} 50' 42''$ W. long.).

Locality 8: North bank of Smoky River, one-half mile west of Watino town site at NW $\frac{1}{4}$ Sec. 24, Twp. 77, Rge. 24, W. 5th Mer., ($55^{\circ} 42' 59''$ N. lat., $117^{\circ} 37' 51''$ W. long.).

Measurements

Measurements of fossils were taken using vernier calipers and vernier beam micrometers. Each measurement was taken four times and the average computed. Parameters for measurements of teeth of horses and camels follow Hay (1913, p. 578); for metapodials of horses and camels, Willoughby (1948, pp. 84-88); and for teeth of mammoths, Osborn (1942, p. 1143). Other skeletal elements were measured using parameters decided upon by the writer.

Anatomical terms follow Sisson and Grossman (1956) and Parker and Haswell (1964). The zoological classification follows Hibbard (1958).

Description of Vertebrate Fossils

Phylum Vertebrata

Class Mammalia

Order Rodentia

Family Sciuridae

Genus Citellus Oken (1816)

Citellus sp.

(Pl. 1, Table 1)

Referred specimen.---Fragmentary right edentulous mandible, UA 1662, from Loc. 8.

Description.---The dorsal parts of the condyloid processes are worn off. The masseteric ridge, weathered dorsally, is sharply defined posteroventrally. The alveolar row curves inward posteriorly. A large alveolus for the incisor extends posteroventrally to the posterior alveolus of the third molar. A well-developed, elongated mental foramen is present anteriorly, but the mandibular foramen posteriorly is partially destroyed by weathering. The alveolar sockets for one premolar and three molars are weathered anteriorly but well-preserved posteriorly. The size of mandibles, development of the masseteric ridge, and number of alveoli in the modern C. lateralis, UAMZ 436,

C. franklini, UAMZ 4473, C. columbianus, UAMZ 3119, and
C. richardsoni, UAMZ 1517, resemble UA 1662.

Order Artiodactyla

Family Camelidae

Genus Titanotylopus Barbour and Schultz (1934)

Titanotylopus sp.

(Pl. 1, Table 2)

Referred specimens.---Lateral distal articular surface of a metapodial, UA 1622, from Loc. 5c.

Description.---The genus Titanotylopus was proposed for a giant camel of Aftonian age from Nebraska (Barbour and Schultz, 1934). Later Barbour and Schultz (1939) named Gigantocamelus, another giant camel of Aftonian age from Nebraska. Webb (1965) has shown Gigantocamelus to be a junior synonym of Titanotylopus.

The distal epiphysis of the metapodial (UA 1622) is ossified and fused to the shaft. The facets for articulation with the proximal phalanx are worn proximally, both anteriorly and posteriorly. The oval depression for attachment of the lateral ligament is worn anteriorly, but the depression on the medial condyle is complete. A roughened area for attachment of the opposite distal articular surface is present proximally near the centre of the depression on the medial condyle. The shaft is convex posteriorly and concave anteriorly. The medial side of the shaft is wider anteroposteriorly than the lateral side. Among materials

examined, the specimen resembles most closely a metapodial of Gigantocamelus (UNSM 27641). On the basis of this resemblance UA 1622 is tentatively referred to Titanotylopus (= Gigantocamelus) Barbour and Schultz.

Genus Camelops Leidy (1854)

Camelops sp.

(Pl. 1, Tables 3-5)

Referred specimens.---Enamel from the anterolingual side of a lower molar, UA 1625, and the anterior part of a ?right M₃, UA 1623, from Loc. 1a. Right P₄, UA 1624, from Loc. 1b. Distal part of a metapodial, UA 1626, from Loc. 1e.

Description.---The genus Camelops Leidy, as defined by Webb (1965), is used in this study.

The selenodont pattern of the little-worn cups of the partial molar (UA 1623) is well-expressed. The anterior lobe is set off from the partial second lobe by a sharp re-entrant angle on the labial side. The lingual face of the molar is almost flat, but ventrally a deep rounded groove is present. The occlusal width of the tooth reaches a maximum 48 mm below the crown. The lobes are elongated anteroposteriorly, convex laterally, and flattened medially.

Part of the lingual enamel of the right P₄ (UA 1624) is worn and abraded posteriorly. The premolar is molariform and bilobed with a small anterolingual inflection. A deep, well-rounded medial groove separates the elongated narrow

anterior lobe from the rounded posterior lobe. An elongated closed pit is present in the posterior lobe. The tooth is flattened on both the anterior and posterior margins.

The epiphyses of two articular facets of a metapodial (UA 1626) are ossified and fused to their shafts. The shafts are flat anteriorly, rounded laterally and posteriorly, and flattened medially. The medial sides of the shafts are wider anteroposteriorly than the lateral sides. The rounded sagittal ridges are well-preserved distally, but weathered proximally. Oval depressions for attachment of ligaments on the lateral and medial side of the condyles are deep and well-preserved. This specimen is tentatively referred to the above genus on the basis of size.

Family Antilocapridae

Genus Antilocapra Ord. (1818)

Antilocapra sp.

(Pl. 11, Table 6)

Referred specimen.---Right maxillary fragment with P²⁻⁴, UA 1661, from Loc. 1c.

Description.---In the second premolar the sharp triangular paracone is separated anterolaterally from a rudimentary parastyle by a shallow V-shaped groove. A deep rounded furrow between the paracone and small metastyle is present. Anterolingually, the protocone or anterior fossette is broken off but posterior to this a worn hypocone or metaconule is present. The posterior root is the longest and twice as thick anteroposteriorly as the anterior root.

In the third premolar the posterior half of the protocone and the anterior part of the hypocone-metaconule complex are broken off. The ?hypocone and ?protoconule are well-preserved. The prominent ridge of the mesostyle separates the high triangular cusps of the metacone and paracone. An incipient parastyle is separated anteriorly from the paracone by a sharp re-entrant angle. The paracone possesses a rounded style on the labial side resembling that of the paracone in the second premolar. A flat-bottomed shallow groove separates the mesostyle and metastyle. An incipient style on the labial side of the metacone is present. The anterior root is the longest; the posterior root is doubled and shorter.

The paracone and protocone of the anterior part of a fourth premolar are preserved. Distal to the prominent ridge of the parastyle is a deep well-rounded groove. The posterior wall of this groove forms the anterior wall of an abraded mesostyle. The ?protoconule bears a sharp pointed cusp and is separated from the parastyle by an angular notch. The paracone bears a worn triangular cusp.

This specimen (UA 1661) resembles the dentition of (UAMZ 3226, juvenile male) Antilocapra americana Ord and is referred to that genus.

Family Bovidae

Genus Bison Hamilton-Smith (1827)

Bison sp.

(Pl. 11, Table 7)

Referred specimen.---Fifth thoracic vertebra, UA 932, from Loc. 5a.

Description.---The distal part of the spinous process is missing, and 2-3 mm is worn off the anterior edge near the base of the spine. The anterior parts of the transverse process are absent bilaterally, but the posterior parts are preserved. The prezygapophyses and anterior costal demifacets are eroded on the margins. The anterior central epiphysis is missing, but the posterior one is complete and partially fused to the centrum. The posterior costal demifacets are worn on their laterodorsal margins; their approximate dimensions were reconstructed with moulding clay.

The specimen was compared with thoracic vertebrae of a specimen identified as Bison occidentalis Lucas (DDMS, Ta-B, 11-22); this skeleton is termed the "Taber" specimen, as it was collected near the town of Taber, Alberta (Trylich and Bayrock, 1966).

In the Taber skeleton the ridge at the midline of the ventral margin of each of the thoracic centra is poorly defined anteriorly but becomes progressively more sharp posteriorly. The ridge in UA 932 resembles that of the 4th, 5th, and 6th thoracic vertebrae of the Taber skeleton.

In the Taber skeleton the width of the neural canal is greater than its height in the first five thoracic vertebrae; the neural canal becomes more nearly circular in the remaining ones. In this respect UA 932 resembles most closely the 4th and 5th thoracic vertebrae.

The postzygapophyses are nearly oval in thoracic vertebrae 1 to 4 but become longer in the more posterior thoracic vertebrae. The facets in UA 932 approximate the shape of the facets in the 5th thoracic vertebra in the Taber specimen. In the Taber skeleton the posterior costal demifacets of the first and second thoracic vertebrae are separated from the transverse processes by the transverse foramen. In the 3rd, 4th, and 5th thoracic vertebrae, the right costal demifacets are fused to the transverse processes and form dual openings of the transverse foramen. A single opening for the transverse foramen is present on the left side of vertebrae 3 to 5, as the left costal demifacet is not

fused to the transverse process. In vertebrae 6 to 9 the posterior costal demifacets and the transverse processes are joined by a shaft of bone that separates the two elements. The left costal demifacet in UA 932 is fused to the transverse foramen. The right costal demifacet is not fused and a single opening is present. These features resemble thoracic vertebrae 3 to 5 of the Taber skeleton.

The angle of the spine with the base of the neural canal of UA 932 is 40° . The smallest angle of the spine in the Taber skeleton is that of the fifth thoracic vertebra: 50° .

From the above comparison, specimen UA 932 resembles most a 5th thoracic vertebra of Bison sp.

Order Perissodactyla

Family Equidae

The most common fossils found in the Saskatchewan gravels are remains of horses. Much of the material is worn and fragmentary.

The Recent horses, zebras, Asiatic and African wild asses and Pleistocene species closely related to them are included in the genus Equus Linnaeus. Linnaeus established Equus with E. caballus, the domesticated horse, as the type species. Later workers have subdivided the genus by placing the living forms into a number of subgenera (Hibbard, 1955a).

Approximately sixty species of Equus have been

described from the Pleistocene of North America. According to Savage (1951) many of the named species seem to be nomina vana. Appraisals of fossils species of Equus should take into account Gidley's study (1901) that demonstrated that many of the characters used in delimiting species of fossil Equus may vary among individuals or age classes and hence have no taxonomic significance.

Hay (1915) doubted the value of studies of fossil materials that depended upon comparisons with modern Equus caballus, as the modern horses have been greatly affected by controlled breeding. He also suggested that identification of species based on single characters or any single index may be unreliable, since variation in specific characters is imperfectly understood.

Savage (1951) suggested that consistent differences in characters may be more important in determination of species than similarities of characters. He stated (p. 244):

It seems practical that if Pleistocene caballine materials in North American are ever to be employed with any degree of certainty in stratigraphic problems, a very strict appraisal of the types is necessitated. Only when types are accompanied by sufficient materials to give at least some indication of infraspecific variation can there be justification for the proposal of a new species among the equines. No objective comparisons may ever be formulated when reference of a specimen from another locality is based on disparate material.

Even with relatively complete materials available, it is seldom possible to achieve unquestionable identification of species.

In the present study all of the equine fossils were recovered from the younger beds of the Saskatchewan gravels. By reference to similarities and differences in enamel pattern and size, the teeth recovered are identified as Equus cf. niobrarensis Hay. Relevant dimensions of holotypes USNM 4999, E. niobrarensis Hay; USNM 7700, E. niobrarensis alaskae Hay, and referred specimen, MMP 46898, E. scotti Gidley, are listed for comparison (Tables 8 to 11).

Equus cf. niobrarensis Hay (1913)

(Pl. II, III and IV)

Referred specimens.---?Left I^1 , UA 1639, from Loc. 1e. Right P^2 , UA 1629, from Loc. 2. ?Right M_1 , UA 1636, from Loc. 3. Left fragmentary maxilla with P^2 , $M^1 - M^3$, UA 1628; right P^2 , UA 1627; right $I^1 - I^3$, and left I^1 , UA 1638, from Loc. 4a. Right M^1 , UA 1633, from Loc. 4b. Left P^2 , UA 1630; right P^2 , UA 1631; right M^1 , UA 1632, from Loc. 4c. Right P_4 , UA 1634, from Loc. 6. Left lower jaw with $P_4 - M_1$, UA 1637, from Loc. 8.

Description.---The first upper incisors (UA 1638) have small medial notches on the labial and lingual borders of the cup as in USNM 4999 (E. niobrarensis). The cup is elongated transversely. The lingual lip of the second incisor (UA 1638) possesses a small notch similar to USNM 4999 (E. niobrarensis). The cup is oval and elongated transversely.

The cup of the third right incisor (UA 1638) is elongated and extends posterolaterally. A deep lingual notch is present. These latter features resemble the third upper incisors of USNM 7700 (E. niobrarensis alaskae). UA 1639 (?left I¹) is weathered and abraded lingually. The labial lip of the cup is straight without medial notches. Dimensions of superior incisors are listed in Table 8.

The preprotoconal groove in the second upper premolars (UA 1628, UA 1630, and UA 1631) is V-shaped and extends labially to approach the anterolingual part of the postprotoconal groove as in USNM 4999 (E. niobrarensis) and USNM 7700 (E. niobrarensis alaskae). In second upper premolars of MMP 46898 (E. scotti), UA 1627, and UA 1629 the preprotoconal groove is weakly developed and separated from the anterolingual part of the postprotoconal groove by a large gap. The preprotoconal groove in the molars of the comparative and Alberta specimens is rounded and extends posteriorly toward the postprotoconal groove.

The protocone in second upper premolars (UA 1627, UA 1628, and UA 1630) is nearly oval but flattened lingually as in MMP 46898 (E. scotti) and USNM 7700 (E. niobrarensis alaskae). The protocone in UA 1631 (P²) is shaped similarly to these but also possesses a small medial inflection lingually. In the latter respect UA 1631 resembles the second premolars of USNM 4999 (E. niobrarensis).

The protocone in upper molars (UA 1628, UA 1632, and UA 1633) is elongated anteroposteriorly and possesses a small

medial inflection lingually that resembles the inflection in MMP 46898 (E. scotti) and USNM 4999 (E. niobrarensis). In USNM 7700 (E. niobrarensis alaskae) the protocone in upper molars is also elongated anteroposteriorly but the small medial inflection on the lingual side is absent.

The postprotoconal groove in premolars and molars of USNM 7700 (E. niobrarensis alaskae), USNM 4999 (E. niobrarensis), and MMP 46898 (E. scotti) is nearly alike in width. However, in UA 1628 (left P²) the postprotoconal groove is nearly twice as wide as in the associated molars. In UA 1633 (right M¹) a seemingly unusual pattern is present: the postprotoconal groove is continuous with the prefossette. This molar was sectioned 15 mm (UA 1633b) and 33 mm (UA 1633c) below the occlusal surface to reveal a continuous connection at 15 mm but a separation of the postprotoconal groove and the prefossette at 33 mm (Pl. III, Figs. 3-5). This feature in UA 1633 is interpreted as an individual variant without taxonomic significance.

The presence or absence of a pli caballin fold in the premolars and molars appears to be an individually variable feature in the sample of Equus from the Saskatchewan gravels. In UA 1628 (P², M¹⁻³) the pli caballin fold is present in the second premolar but not in the associated molars. A first right upper molar (UA 1632) possesses a weakly-developed pli caballin fold at the occlusal surface. This molar was sectioned 27 mm (UA 1632b) below the crown to reveal the absence of the pli caballin fold at that level (Pl. III, Figs. 1 and 2).

In the comparative specimens the pli caballin fold is well-developed.

The enamel of the prefossette of a left P^2 (UA 1628) is more crenulated than in the associated molars, resembling in this regard MMP 46898 (E. scotti). The anterior and posterior fossettes are confluent in the left second premolar (UA 1628); in this individual the fossettes in the first and second molars are in contact. The fossettes are in contact in USNM 7700 (E. niobrarensis alaskae); they are separated by a distinct gap in USNM 4999 (E. niobrarensis) and MMP 46898 (E. scotti).

The length of the occlusal surface in the upper cheek teeth (UA 1628, left P^2 , M^{1-2} ; UA 1629, right P^2 ; UA 1630, left P^2 ; UA 1631, right P^2 ; UA 1632, right M^1 ; and UA 1633, right M^2) is greatest at the crown; it is not in UA 1628 (left M^3 , unerupted). The greatest occlusal length of this molar is located 40 mm below the crown.

All upper premolars and molars collected and those of the comparative specimens have a deep rounded hypoconal groove. The external groove between the parastyle, mesostyle, and metastyle is similarly well-developed. Dimensions of upper cheek teeth are listed in Table 9.

In lower molars of USNM 4999 (E. niobrarensis) and MMP 46898 (E. scotti) the hypolophid extends between the metaconid and metastylid. In lower molars of USNM 8226 (E. lambei) the hypolophid does not extend between the metaconid and metastylid. UA 1636 (right M_1) and UA 1634 (left P_4)

were sectioned 15 mm below the occlusal surface; the hypolophid extends between the metaconid and metastylid in UA 1636 but not in the premolar UA 1634 (Pl. IV, Figs. 4-7) resembling in this regard MMP 46898 (E. scotti) and USNM 4999 (E. niobrarensis).

The premolars of the left half of a lower jaw of a young individual (UA 1637) are complete; the posterior half of the first molar is absent. A section of bone was removed from the lingual side of the jaw to expose the roots of the premolars (Pl. IV, Fig. 3, Tables 10 and 11).

Dimensions of lower cheek teeth are listed in Table 11.

Equus sp.

(Pl. V, Tables 12-20)

Referred specimens.---Incomplete left tibial tarsal, UA 1649; proximal part of a radius, UA 1651; distal part of a scapula, UA 1658; second phalanx, UA 1663, from Loc. 1a. Right third metacarpal, UA 1645, from Loc. 1d. Distal part of a tibia, UA 1657, from Loc. 1e. Left fibular tarsal, UA 1648; proximal part of a radius, UA 1652; distal part of a radius, UA 1653, from Loc. 1f. Left fibular tarsal, UA 1647, from Loc. 1g. Left femur, UA 1640; right third metatarsal, P 1646; first phalanx, UA 1659, from Loc. 4a. First phalanx, UA 1660, from Loc. 4b. Right third metatarsal, UA 1643; partial limb and foot including distal part of the right radius, metacarpals, carpals, sesamoids, and phalanges, UA 1644; left innominate, UA 1665; distal end of humerus,

UA 1675, from Loc. 4c. Right femur, UA 1641; edentulous lower jaw, UA 1642; incomplete left fibular tarsal, UA 1650; proximal part of a left tibia, UA 1656; left innominate, UA 1666, from Loc. 5b. Distal extremity of a left tibia, DO 1655, from Loc. 7.

Description.---The left lingual half of the edentulous lower jaw (UA 1642) is worn and shattered, but impressions of lower teeth ($P_3 - M_2$) are present in the preserved bone.

Only the distal part of a left scapula comprises UA 1658; the fossil is abraded, and the lateral part of the oval glenoid cavity is broken off. The rim of the remainder of the cavity is worn and abraded. The coracoid process is missing; the blunt tuber scapula on the posterior part of the scapula is complete. The tuber scapula extends medially to form the depressed ventral part of the subscapular fossa in normal fashion as in domestic horses.

A fragmentary distal epiphysis of a humerus (UA 1675) is not well enough preserved to permit measurement. The distal part of the medial facet for articulation with the radius is abraded but the proximal part is smooth and well-preserved. A low rounded sagittal ridge on the lateral condyle is separated from the medial condyle by an abraded shallow sagittal groove. The rounded shallow depression for attachment of the medial ligament is abraded anteriorly.

A right radius (UA 1651) is represented only by a proximal fragment that includes the surface of articulation with the humerus. The fragment is weathered on its antero-

medial side. The lateral tuberosity for attachment of the biceps tendon is also abraded.

The radius of UA 1644 is represented only by a distal fragment. The fragment displays well-preserved facets for articulation with the proximal row of carpals. Here the medial facet is the largest, quadrilateral in shape, concavo-convex anteroposteriorly, and articulates with the radial carpal. The intermediate facet, for the intermediate carpal, is similar in form, but smaller; the lateral facet, for the ulnar and accessory carpals, is smallest.

On the shaft of UA 1644 (right radius) the anterior groove for the tendon of the common digital extensor is distinct. Lateral to the anterior groove stands the roughened tuberosity for attachment of the common digital extensor muscle. The lateral surface of the radius is bordered medially by the shallow groove for passage of the lateral extensor tendon. On the posterior surface, laterally, is a roughened tuberosity for attachment of the lateral ligament of the carpal joint. All of the other radii recovered are more fragmentary than that in UA 1644.

The proximal and distal rows of the carpals in UA 1644 are essentially complete; only the first distal carpal is missing. As preserved, the radial carpal is the largest member of the proximal row and exhibits its characteristic slight lateral compression. The proximal surface for articulation with the medial facet of the radius, and the distal surface for articulation with the second and third

carpals are undamaged. Dorsal and ventral facets, in contact with the intermediate carpal, are well-defined.

The intermediate carpal shows its saddle-shaped proximal surface for reception of the middle facet of the radius. The smaller distal surface, articulating with the third and fourth carpals, is also well-preserved. On the medial surface are impressed distinct oval facets for articulation with the radial carpal. Similarly shaped facets for articulation with the ulnar carpal are preserved without damage on the lateral surface of the intermediate carpal.

The ulnar carpal is the smallest of the proximal row and articulates by its concave proximal facet with the lower part of the lateral facet of the radius. The preservation of the distal surface shows the ventrally oblique articulation of that surface with the fourth carpal. Posteriorly the concave facet for articulation with the accessory carpal is preserved in its entirety.

The accessory carpal is slightly weathered posterodorsally. Its medial surface is concave and smooth and bears a number of small foramina distally; its lateral surface is convex and irregular. The smooth and rounded anterolateral groove for passage of tendons has not been affected by weathering. The anterior border exhibits its two facets in undamaged condition: the upper one is concave and contacts the back part of the lateral facet of the radius; the lower one is convex and contacts the ulnar carpal.

As preserved, the distal row of carpals in UA 1644 consists of the second, third, and fourth carpals; the first carpal was not recovered. On the proximal surface of the second carpal the elongated, convex and oval facet for articulation with the radial carpal bone is distinct. The external surfaces of the second carpal exhibits the eminence for attachment of the collateral ligament, although this is abraded. The internal surface plainly displays its two elongated facets for articulation with the third carpal bone. Posteroventrally the small rounded facet for articulation with the posterior part of the third carpal is present. Posterior to the latter facet the second carpal possesses an undamaged small rectangular facet for articulation with the first carpal.

The third carpal, the largest of the distal row, bears irregular facets for articulation with the intermediate, radial, second and fourth carpals, and second and third metacarpals. The third carpal is flattened and approximately twice as wide in front as behind. Its convex anterior surface is crossed by a smooth transverse ridge; its posterior surface, relatively small and rounded, bears a smooth tuberosity for attachment of ligaments.

In the fourth carpal, the convex proximal surface for articulation with the intermediate and ulnar carpals is well-defined. The distal surface exhibits the paired angular facets for articulation with the third metacarpal.

The third metacarpal in UA 1644 is nearly complete

but does show distal weathering. The damage extends to the high sagittal ridge that separates the rounded lateral and medial condyles. On either side of the condyle is preserved in undamaged condition the small fossa and tubercle to which the collateral ligaments are attached. The metacarpal tuberosity is slightly weathered. The smooth irregular facets for the distal row of carpals are distinct. UA 1643 and UA 1645, agree with UA 1644 in features exhibited.

The second and fourth metacarpals of UA 1644 are worn distally, but the proximal rounded facets are complete and well-preserved.

The proximal sesamoids of UA 1644 are essentially undamaged. The lateral proximal sesamoid, concave laterally and convex medially, exhibits the concave anterior semicircular facet for articulation with the posterior surface of the third metacarpal. The medial proximal sesamoid, convex medially and concave laterally, shows its semicircular anterior facet for articulation with the third metacarpal.

The lateral part of the distal sesamoid (UA 1644) is broken off. The proximal border, wide and grooved in its middle, and narrower and rounded on each side, is complete. The distal surface, carrying the anterior facet for articulation with the third phalanx, has not been marred by weathering.

The right first phalanx of UA 1644 exhibits little post-mortem damage. The proximal extremity shows two concave glenoid cavities for articulation with the third

metacarpal. On each side of the glenoid cavity is a posteriorly directed tuberosity for ligamentous attachment. The eminence for attachment of the extensor tendons is abraded. The distal part of the phalanx displays two convex condyles for articulation with the proximal end of the second phalanx. On the lateral and medial side above the condyles of UA 1659 are the shallow grooves and small tuberosities to which the collateral ligaments attached.

The second phalanx of UA 1644 is abraded anteromedially but specimen UA 1663 is complete. In the latter specimen the proximal extremity exhibits the two cavities for articulation with the distal end of the first phalanx. On the mid-part of the anterior dorsal border is seen the roughened area for attachment of the common extensor tendon. On either side of the posterior dorsal border stands a small tuberosity presumably for ligamentous and tendoninous attachments. Distally a shallow groove surmounted by a roughened eminence for attachment of the collateral ligament and the superficial flexor tendon is well-defined. The distal extremity bears the two condyles for articulation with the proximal end of the third phalanx.

The lateral part of a third phalanx (UA 1644) is not well enough preserved to yield meaningful measurements. The extensor process for attachment of the collateral ligament is abraded. Posterior and ventral to this process the two concave facets for articulation with the distal end of the second phalanx are distinct. Laterally, incised into the

bone, is an unworn oval depression for attachment of the collateral ligament and ventral to this is the groove for passage of the dorsal artery. Posterior and directed obliquely forward lies the rounded volar groove; fossilization of the surface of the bone has preserved the attachment for the deep flexor tendon.

Two left innomimates (UA 1665 and UA 1666) are worn and incomplete but resemble one another in that they both possess a well-preserved acetabulum, part of the ventromedial branch of the pubis, part of the anterodorsal part of the iliac shaft, and part of the posteroventral part of the acetabular shaft. The wing of the ilium, the body of the ischium, and the symphyseal branch of the pubis are lacking from these specimens.

A left femur (UA 1640) is very nearly complete. In transverse section the shaft is, in general, rounded, but its flattened posterior surface and greater posterior width appear not to be the result of post-mortem deformation. The shaft is smooth laterally and medially; its anterior surface, however, displays a central roughened line proximally for attachment of muscles. The middle part of the shaft for attachment of the adductor muscle is worn smooth by post-mortem abrasion. The trochanter minor exhibits distinct muscle scars unaltered in preservation. Distal to the trochanter tertius the lateral and medial supracondyloid crests are distinctly separated by an elongated supracondyloid fossa; in this depression the superficial digital flexor originated.

The rounded head of the femur is directed antero-medially; the fovea capitis, in which accessory and round ligaments attached, is plainly imprinted into the surface of the head. The neck is abraded anteriorly and posteriorly. The posterior part of the trochanter major lies posterior to the plane of the head and is elevated above it as is normal in horses; distal parts of the trochanter are missing in UA 1640. The posterior extent of the trochanter major forms the lateral wall of the large trochanteric fossa.

The distal part of UA 1640 is slightly weathered anteromedially, but insufficiently to obscure the features of the trochlea. As preserved, this consists of two worn ridges separated by a groove in which the medial ridge is more prominent and extends more proximally and anteriorly than the lateral one. Posteriorly the large medial and smaller lateral condyles are separated by a deep and rounded intercondyloid fossa. Between the lateral condyle and the trochlea lies a roughened depression for attachment of the extensor digitalis longus tendon.

The proximal part of a left tibia (UA 1656) is abraded posteriorly, so that the rims of the saddle-shaped medial and lateral condyles are damaged. However, the spine or intercondyloid eminence remains, so that the two condyles are well-separated. On the periphery of the spine four shallow semicircular intercondyloid fossae are preserved. The largest of these is posterior to the spine and grades into a smooth rounded popliteal notch, continuous with the shaft, but separating the medial and lateral condyles. The facet on

the lateral condyle for attachment of the fibula is broken off. The anterior border of the lateral condyle that forms the wall of a deep semicircular groove—the sulcus muscularis, for passage of tendons—is undamaged, as is the anterior eminence with its lateral semicircular groove for attachment of the middle patellar ligament. The shaft in transverse section is triangular and bears posteriorly roughened lines for attachment of muscles.

A left fibular tarsal (UA 1647) lacks only the distal part of the tuber calcis. The medial surface of the body is not damaged, so that the sustentaculum tali is in place. This process exhibits its two articulating facets, one small, oval, anterior, and abraded, the other larger, semicircular, and ventral, for articulation with the tibial tarsal. Lateral and ventral to the sustentaculum tali, the three additional facets for articulation of the tibial tarsal are evident, but show indications of weathering.

The medial half of a left tibial tarsal (UA 1649) is weathered laterally. The medial trochlear ridge extends anterolaterally and posteriorly. It is bounded laterally by a deep, worn, and rounded groove. Ventral to the antero-dorsal part of this groove is a large elongate facet for articulation with the semicircular facet on the sustentaculum tali of the fibular tarsal. The medial surface of the tibial tarsal possesses a distal roughened area for attachment of the medial ligament.

The distal part of the right third metatarsal (P 1646)

is missing; otherwise the bone is nearly complete. The anterior and concave articular surface is marked by a large non-articular depression that is closed medially but extends laterally to the edge of the bone. In domestic horses this depression is semicircular, extending posteromedially and posterolaterally to the edge of the bone. The facets for articulation with the tarsals and small metatarsals are abraded and incomplete.

These fossils clearly pertain to Equus; their features, however, are not explicit enough to permit reference to a species of that genus.

Order Proboscidea

Family Elephantidae

Genus Mammuthus Burnett (1830)

The premolars and molars of mammoths consist of plates of cement, dentine, and enamel oriented transversely to the long axis of the tooth. To distinguish different species, the number of ridge plates per 100.0 mm, the thickness of enamel plates, and distance between successive enamel plates are determined. There are fewer ridge plates present in premolars than in molars. The third molars (M3) are the largest and possess the greatest number of ridge plates; for the Columbian mammoth (M. columbi), there are generally 19 in the upper and 16+ in the lower (M3 19/16+); the Jefferson mammoth (M. jeffersoni) possesses 25 in the upper and 24 in the lower (M3 25/24); and woolly mammoths (M. primigenius)

typically possess 24-27 in both the upper and lower third molars (Osborn, 1942). The range of ridge plates per 100.0 mm reported by Osborn (1942) are from five and one-half to eight and one-half for the Columbian mammoths; eight to eleven and one-half for the Jefferson mammoths; and eight to thirteen for the woolly mammoths. Since the ridge plates are more arcuate and more compressed near the dental crown, the count should be taken halfway between the occlusal surface and the base of the tooth, both on the internal and external sides, if accuracy is to be assured.

Mammuthus cf. columbi Falconer (1857)

Columbian mammoth

(Pl. V, Table 21)

Referred specimens.---Incomplete lower molar, UA 1669; incomplete molar, UA 1673, from Loc. 5c.

Description.---An incomplete left lower molar (UA 1669) consisting of two fragments is composed of eight unworn and six worn enamel ridge plates. There are five and one-half ridge plates per 100.0 mm on the lingual side, six ridge plates per 100.0 mm on the labial side, four and one-half unworn ridge plates per 50.0 mm on the midline of the grinding surface posteriorly, and two and one-half worn ridge plates per 50.0 mm on the midline of the grinding surface anteriorly. The average thickness of enamel of the plates measured on the crown is approximately 3.0 mm. The

labial and lingual borders of the worn enamel ridge plates are concave anteriorly as in the third molar of MMP 42222 (M. columbi). UA 1669 is assigned to the above species because the thickness of enamel and count of ridge plates agree with the Michigan specimen.

Part of a tooth (UA 1673) consists of two and one-half worn ridge plates in 35.0 mm measured on the midline of the grinding surface. This specimen is assigned to M. columbi as the number of ridge plates in 100.0 mm (extrapolated) fall within the range of that species.

Mammuthus sp.

(Table 21)

Referred specimens.---Two fragments of teeth, UA 1672 and UA 1674, from Loc. 4c.

Description.---The teeth are abraded and shattered. Specimen UA 1672 consists of one ridge plate surrounded by cement and dentine. Specimen UA 1674 is a little larger; it consists of one and one-half ridge plates.

?Mammuthus sp.

(Tables 22 and 23)

Referred specimens.---Incomplete tusk, UA 1668; incomplete tusk, UA 1667, from Loc. 4c. Fragmentary right scapula, TE 1670, from Loc. 5c. Tusk not collected from Loc. 4d (Frontispiece).

Description.---Specimen UA 1667 is the larger and has a diameter of 97.0 mm at the alveolus. UA 1668 is too poorly preserved to determine meaningful dimensions or permit description.

The anterior, posterior, and dorsal borders of a right scapula (TE 1670) are worn and incomplete. The distal part of the scapular spine terminates in a roughened crest directed 80.0 mm laterally from the surface of the neck. The large oval glenoid cavity is worn and weathered.

DISCUSSION AND CONCLUSIONS

In comparison with the modern fauna of the Great Plains, the distinctive fossils from the Saskatchewan gravels are giant camel (Titanotylopus), camel (Camelops), Columbian mammoth (Mammuthus cf. columbi), and horse (Equus cf. niobrarensis).

The ground squirrel (Citellus) has been found in deposits ranging from Pliocene to Recent (Hibbard, et al., 1965), and is of little use in determining the age of the Saskatchewan gravels.

The genus Antilocapra has been reported from the Rancho la Brea and McKittrick deposits of California (Frick, 1937). The genus is not known from deposits earlier than the Wisconsin (Hibbard, 1958).

Camelops sp. is known from the Nebraskan to the Wisconsin (Hibbard, et al., 1965). A camel the size of Titanotylopus (= Gigantocamelus) is known from deposits ranging in age from Late Pliocene to Yarmouth (Hibbard, 1967, written communication). In Nebraska, Titanotylopus is known from the Aftonian (Schultz, et al., 1951).

The type locality of Equus niobrarensis Hay near Hay Springs, Nebraska, is assigned to the Irvingtonian and Rancholabrean Provincial Ages (Hibbard, et al., 1965).

The earliest occurrence of Bison in North America is thought to be from Yarmouth sediments (Schultz, et al., 1951). Hibbard (1955b) questioned this assignment and regards

the first appearance of Bison to be not earlier than the Illinoian glacial stage (see also Repenning, 1967).

The first appearance of the genus Mammuthus in North America is late Kansan (Meade, 1953; Hibbard, et al., 1965). Osborn (1942) tentatively suggested that the ancestors of M. columbi Falconer migrated to North America during the Second Interglacial (Yarmouth) or possibly the First Interglacial (Aftonian). The type locality of M. columbi is in Georgia in the southeastern United States. In this locality Bison ?latifrons, was found in association with remains of M. columbi (Hay, 1923). Hay (1923) thought this faunal assemblage was of Aftonian age. The early attempts of Hay to establish a faunal succession correlating with each glacial and interglacial epoch, based largely on paleontological grounds, have been largely discredited (Russell, 1959). In North America remains of M. columbi Falconer have not been found in deposits earlier than the Sangamon Interglacial (Hibbard, 1958). In Nebraska Schultz, et al., (1951) thought M. columbi was of middle Wisconsin age.

The remains of Titanotylopus sp. and M. columbi were found in older (higher) beds of the Saskatchewan gravels (Loc. 5c) than the remains of Bison (Loc 5a). Present knowledge of the temporal (vertical) distribution of Titanotylopus sp. suggests that this genus is not younger than Yarmouth. Consequently, the high-level Saskatchewan gravels in the Edmonton District are of Yarmouth age or older. M. columbi could be as old as Yarmouth in central Alberta.

Conceivably, on the other hand, Titanotylopus sp. or camels of this size may have survived in central Alberta up to the Late Pleistocene and the vertical range of M. columbi need not be extended.

The evidence from fossil Bison and Antilocapra suggests that at least part of the Saskatchewan gravels in central and southern Alberta may be properly assigned to the Rancholabrean Provincial Age (Illinoian-Wisconsin). Indeed, the presence of the pronghorn (Antilocapra) suggests that the youngest age for some of the sediments in southern Alberta is as late as Wisconsin. On evidence provided by Bison, some of the Saskatchewan gravels in central Alberta may be as young as the Illinoian.

The several levels of the Saskatchewan gravels in the study area are heterochronous and can not be assigned with any degree of certainty to a specific time on evidence provided by the recovered samples. However, it is certain that areas in central and southern Alberta where Saskatchewan gravels occur were not glaciated by continental ice during the Nebraskan and Kansan glacial stages.

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APPENDIX A:

STRATIGRAPHIC DESCRIPTIONS OF LOCALITIES
AND FOSSIL POSITIONS IN THE SASKATCHEWAN GRAVELS

The sections were measured and described during the summer of 1967, and text descriptions are presented (p. 50 - 66).

Munsell Color Formulae for Qualitative Terms used
in Stratigraphic Descriptions

Qualitative Terminology	Munsell Color Formulae
white	N9
grey, dark grey	N5 to N7
grey-brown	5YR 4/1 to 5YR 6/1
pale blue	5B 7/1
yellow, buff	5Y 7/2 to 5Y 6/4
yellow-brown	5Y 5/6
reddish-brown, rusty-brown, rusty .	10R 3/4 to 10R 4/6
red	5R 4/6
brown	10R 3/4 to 10R 4/6
green	10GY 5/2
black	N1 to N2

Locality 1a: Elevation of bedrock---2100 feet \pm above
sea-level.
Lat. 50⁰ 08' 00" N., long. 110⁰ 39' 42" W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Gravel and sand; interbedded; pebbles to
boulders; terrace deposits. 20

Silt; horizontally bedded; minor amounts
of pebbles. 0.5-8

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand; pebbles
to boulders, 0.5"-8" long diameter; sub-
rounded to well-rounded; matrix (2-3%)
of coarse, angular sand, well-cemented;
pebbles coated with iron crust; composed
dominantly of brown and red quartzites,
with minor amounts of chert, argillites,
basic volcanics, coal, and bedrock frag-
ments. 6-12+

(a) Equus sp., distal end of left scapula,
UA 1658, 11 feet above base of unit.

(b) Equus sp., left tibial tarsal, UA
1649, eight feet above base of unit.

(c) Equus sp., proximal end of a radius,
UA 1651, 6.5 feet above base of unit.

(d) Equus sp., second phalanx, UA 1663,
4 feet above base of unit.

(e) Camelops sp., ?RM₃, UA 1623, 1 foot
above base of unit.

(f) Camelops sp., enamel of lower molar,
UA 1625, 1 foot above base of unit.

Talus 2

Foremost Formation (Upper Cretaceous):

Shale; silty. 3+

Locality 1b: Elevation of bedrock---2110 feet \pm above
sea-level.
Lat. $50^{\circ} 06' 08''$ N., long. $110^{\circ} 41' 20''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Gravel and sand; interbedded. 25

Sand; silty; horizontally bedded; minor
amounts of pebbles. 3

Saskatchewan gravels (Pleistocene):

Gravel and sand; pebbles to boulders,
0.5"-6" long diameter; subrounded;
poorly sorted; sand; rusty-brown; more
sand near base of unit; pebbles composed
dominantly of brown quartzites, with
minor amounts of cherts, basic volcanics,
coal, and bedrock fragments. 16

(a) Camelops sp., RP₄, UA 1624, 7 feet
above base of unit.

Foremost Formation (Upper Cretaceous):

Shale; silty; soft; fissile. 4 +

Locality 1c: Elevation of bedrock---2140 feet \pm above
sea-level.
Lat $50^{\circ} 05' 52''$ N., long. $110^{\circ} 41' 20''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; yellowish-brown; inclusions of
gravel and sand; slumped.

150 \pm

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand;
contorted upper contact; pebbles to
boulders; subrounded to well-rounded;
poorly sorted; pitted; composed
dominantly of brown quartzites, and
green argillites.

7

Sand; medium- to coarse-grained; cross-
bedded; poorly sorted; rusty-brown;
minor amounts of pebbles.

3

(a) Antilocapra sp. Ord, right
maxillary fragment with P²⁻⁴, UA 1661,
3 feet above base of unit.

Foremost Formation (Upper Cretaceous):

Shale; silty; grey; soft; fissile.

4 +

Locality 1d: Elevation of bedrock---2115 feet \pm above
sea-level.
Lat. $50^{\circ} 04' 29''$ N., long. $110^{\circ} 38' 00''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; buff, inclusions of gravel and sand. 120 \pm

Sand; silty; with minor amounts of clay;
horizontally bedded; unit discontinuous. 0-3

Saskatchewan gravels (Pleistocene):

Sand, with minor amounts of gravel and silty
lenses; medium-to fine-grained; sub-
rounded; well-sorted; loosely cemented;
cross-bedded; foresets are stained yellow,
red, brown, pale blue; pebbles composed
dominantly of chert and quartzite with
minor amounts of coal, and bedrock frag-
ments near the base. 35

Gravel, pebbles to boulders, 0.5"-4" long
diameter; poorly sorted; cemented; sub-
rounded; composed dominantly of brown
and red quartzites, with minor amounts
of chert, basic volcanics, fragments. 0.5

(a) Equus sp., right third metacarpal,
UA 1645, 33 feet above base of unit.

Foremost Formation (Upper Cretaceous):

Shale; sandy; reddish-brown, compact. 3+

Locality 1e: Elevation of bedrock---2135 feet \pm above
sea-level.
Lat. 50° 05' 00" N., long. 110° 39' 20" W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Clay; horizontally bedded; minor amounts of pebbles.	2
Gravel and sand; pebbles to boulders, cross- bedded; glacio-fluvial.	55
Sand, silty; yellowish; horizontally bedded; minor amounts of pebbles.	4

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand and silt; pebbles to boulders, 0.5"-8" long diameter; subangular to subrounded; well- sorted; composed dominantly of brown and red quartzites, with minor amounts of cherts, basic volcanics, coal, argillites, and bedrock fragments; cross-bedded sand lenses up to 16" thick; medium- to fine- grained sand; subangular to subrounded; rusty-brown; composed dominantly of quartz and chert.	27
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- (a) Equus sp., distal part of tibia, UA
1657, 1 foot above base of unit.
- (b) Equus cf. niobrarensis Hay, ?LI¹, UA
1639, 1 foot above base of unit.
- (c) Camelops sp., distal end of a
metacarpal, UA 1626, 1 foot above base of
unit.

Foremost Formation (Upper Cretaceous):

Shale; silty; greenish; fissile.

Locality 1f: Elevation of bedrock---2140 feet \pm above
sea-level.
Lat. 50° 05' 21" N., long. 110° 41' 12" W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till, with minor inclusions of gravel and sand; yellowish-brown.	110 \pm
Silt; horizontally bedded; minor amounts of pebbles.	3

Saskatchewan gravels (Pleistocene):

Sand, with minor amounts of gravel; medium- to coarse-grained; cross- bedded; poorly sorted; rusty-brown.	10
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- (a) Equus sp., distal end of a radius,
UA 1653, 7 feet above base of unit.
- (b) Equus sp., distal end of a radius,
UA 1652, 3 feet above base of unit.
- (c) Equus sp., left fibular tarsal,
UA 1648, 2 feet above base of unit.

Foremost Formation (Upper Cretaceous):

Shale; sandy; compact.	5 +
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Locality 1g: Elevation of bedrock---2125 feet \pm above
sea-level.
Lat. 50° 08' 16" N., long. 110° 38' 28" W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till, with sand and gravel inclusions.	180 \pm
Silt; yellow, paler near top.	10

Saskatchewan gravels (Pleistocene):

Sand, with minor amounts of gravel (see 1f).	6
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- (a) Equus sp., left fibular tarsal, UA
1647, 4 feet above base of unit.

Foremost Formation (Upper Cretaceous):

Shale; silty.	10 +
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Locality 2: Elevation of bedrock---2745 feet \pm above
sea-level.
Lat. $49^{\circ} 41' 42''$ N., long. $112^{\circ} 51' 30''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; dark grey; massive. 100 \pm

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand; pebbles to boulders, 0.5"-14" long diameter; sub-rounded; frost action structures in upper part; poorly sorted; loosely cemented; composed dominantly of brown and buff quartzites, with minor amounts of basic volcanics, limestones, red arkosic sandstones, green siltstones, coal, conglomerates, and bedrock fragments. 8 +

(a) Equus cf. niobrarensis Hay, RP², UA 1629, 5 feet below top of unit.

Bedrock not exposed.

Locality 3: Elevation of bedrock---2760 feet \pm above
sea-level.
Lat. $52^{\circ} 16' 09''$ N., long. $113^{\circ} 50' 53''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; yellow-brown; columnar. 18

Saskatchewan gravels (Pleistocene):

Gravel, with minor sand lenses; deranged pebbles in upper nine feet; contact with overlying till contorted; pebbles to boulders, 0.5"-10" long diameter; sub-angular to well-rounded; poorly sorted; loosely cemented; composed dominantly of brown quartzites, with minor amounts of limestones, cherts, feldspathic quartzites, and bedrock fragments near the base.

(a) Equus cf. niobrarensis Hay, ?RM₁, UA 1636, 2 feet above base of unit.

Edmonton Formation (Upper Cretaceous):

Shale; grey. 18 +

Locality 4a: Elevation of bedrock---2320 feet \pm above
sea-level.
Lat. $52^{\circ} 57' 32''$ N., long. $112^{\circ} 58' 56''$ W.

	Thickness (feet)
Glacial Drift (Pleistocene):	
Till; yellowish-brown; sandy.	18
Till; grey-brown; clayey.	2
Silt; buff; horizontally laminated; minor amounts of pebbles.	1-2
Saskatchewan gravels (Pleistocene):	
Gravel, with discontinuous sand and silt lenses, 0.5"-4" thick; pebbles to boulders, 0.5"-14" long diameter; subrounded; loosely cemented; poorly sorted; matrix of medium- to fine-grained sand, subangular to sub- rounded; silt stringers in upper four feet; pebbles composed dominantly of brown quartzites (approximately 95%), with minor amounts of cherts, limestones, sandstones, coal and bedrock fragments; iron and manganese staining throughout.	19
(a) <u>Equus</u> cf. <u>niobrarensis</u> Hay, RP ² , UA 1627, 16 feet above base of unit.	
(b) <u>Equus</u> cf. <u>niobrarensis</u> Hay, RI ^{1,2,3} , LI ¹ , UA 1638, 9 feet above base of unit.	
(c) <u>Equus</u> sp., left femur, UA 1640, 4 feet above base of unit.	
(d) <u>Equus</u> cf. <u>niobrarensis</u> Hay, left half of upper jaw with P ² -M ³ , UA 1628, 4 feet above above base of unit.	
(e) <u>Equus</u> sp., right third metatarsal, 1646*, from talus.	
(f) <u>Equus</u> sp., first phalanx, UA 1659*, from talus	
Talus	3
Edmonton Formation (Upper Cretaceous):	
Shale; sandy; grey; soft.	2 +

* Specimens from the Saskatchewan gravels; the till
has been stripped in preparation for mining
(Polege's Pit).

Locality 4b: Elevation of bedrock---2345 feet ± above
sea-level.
Lat. 52° 57' 32" N., long 112° 58' 56" W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; sandy; brown; columnar. 4.5

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand; pebbles
to boulders, 0.5"-14" long diameter; sub-
angular to well-rounded; loosely cemented;
pitted; matrix of medium-to very fine-
grained sand; well-sorted; subangular;
loosely cemented; mainly quartz and chert;
pebbles composed dominantly of brown and
feldspathic quartzites, with minor amounts
of black and red cherts, argillites, coal
and bedrock fragments. 19+

(a) Equus cf. niobrarensis Hay, RM¹, UA
1633, 4 feet below top of unit.

(b) Equus sp., first phalanx, UA 1660*,
from talus.

(c) ?Mammuthus sp., partial tusk, UA 1668,
8 feet below top of unit.

Talus 4+

Bedrock not exposed.

* Specimen from the Saskatchewan gravels; the till has
been stripped for mining (Falconberg's Pit).

Locality 4c: Elevation of bedrock---2340 feet \pm above
sea-level.
Lat. 52° 56' 55" N., long. 112° 58' 34" W.
Thickness
(feet)

Glacial Drift (Pleistocene):

Till, sandy; yellowish-brown. 8

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand; weathered
yellow-brown; pebbles to boulders, 0.5"-12"
long diameter; subrounded to well-rounded;
some pebbles coated with manganese, composed
dominantly of pitted quartzites, with minor
amounts of cherts, coal, and bedrock frag-
ments. 19

(a) Equus sp., right third metatarsal, UA
1643, 2 feet above base of unit.

(b) Equus sp., distal end of right radius
with associated carpals, metacarpals, sesa-
moids, and phalanges, UA 1644, 0.5 feet
above base of unit.

(c) Equus cf. niobrarensis Hay, LP², UA
1630 *, from talus.

(d) Equus cf. niobrarensis Hay, RP², UA
1631 *, from talus.

(e) Equus cf. niobrarensis Hay, RM¹, UA
1632 *, from talus.

(f) Equus sp., left innominate, UA 1665, *
from talus.

(g) Equus sp., distal end of a humerus,
UA 1675*, from talus.

(h) Mammuthus sp., partial molar, UA 1672 *,
from talus.

(i) Mammuthus sp., partial molar, UA 1674 *,
from talus.

(j) ?Mammuthus sp., partial tusk, UA 1667 *,
from talus.

Talus 2

Edmonton Formation, (Upper Cretaceous):

Shale; sandy. 1+

* Specimens from the Saskatchewan gravels; the till has
been stripped for mining (County Pit).

Locality 4d: Elevation of bedrock---2375 feet \pm above
sea-level.
Lat. $52^{\circ} 52' 47''$ N., long. $112^{\circ} 43' 56''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; sandy.

8

Saskatchewan gravels (Pleistocene):

Gravel and sand; interbedded; unit
contorted throughout; regional dip of
strata is 11° south at 178; beds vary
from 4"-8" in thickness; pebbles
0.25"-2" long diameter; well-rounded
to tabular; loosely cemented; composed
dominantly of pitted quartzites, with
minor amounts of cherts, sandstones,
and bedrock fragments; sand is medium-
to very fine-grained; subangular;
cemented, oscillation ripple marks
dominant; salt and pepper texture;
rusty-brown; composed dominantly of
red and black cherts and quartz grains.

15 +

(a) ?Mammuthus sp., fragmentary tusk,
not collected (see Frontispiece), 12
feet below top of unit.

Bedrock not exposed.

Locality 5a: Elevation of bedrock---2050 feet \pm above
sea-level.
Lat. 53⁰ 29' 22" N., long. 113⁰ 36' 58" W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Silt, with interbedded clay and fine sand;
horizontally bedded; minor amounts of
pebbles. 9

Till; clayey; upper part yellow-brown;
lower part grey. 25

Saskatchewan gravels (Pleistocene):

Sand, with minor amounts of gravel; buff;
crossbedded; fine-to medium-grained; sub-
angular to well-rounded; well-sorted; rare
microfaulting; abundant bedrock fragments
near base. 32

(a) Bison sp., fifth thoracic vertebra,
UA 932, 15 feet below top of unit.

Talus 10

Edmonton Formation (Upper Cretaceous):

Shale; grey; bentonitic; loosely cemented;
small stringers of coal up to 4" in
thickness; thin sandstone beds. 9+

Locality 5b: Elevation of bedrock---2050 feet \pm above
sea-level.
Lat. $53^{\circ} 29' 15''$ N., long. $113^{\circ} 19' 24''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; sandy; rusty-brown. 14

Saskatchewan gravels (Pleistocene):

Sand, with minor amounts of gravel;
yellow-brown; frost action structures
in upper eight feet; medium- to fine-
grained; well-sorted; loosely cemented;
salt and pepper texture; mainly chert
and quartz. 45 +

(a) Equus sp., right femur, UA 1641,
23 feet above base of unit.

(b) Equus sp., left innominate, UA 1666,
23 feet above base of unit.

(c) Equus sp., proximal end of a left
tibia, UA 1656, 10 feet above base of
unit.

(d) Equus sp., edentulous lower jaw,
UA 1642, 2 feet above base of unit.

(e) Equus sp., partial left fibular
tarsal UA 1650, 2 feet above base of
unit.

Talus 3

Edmonton Formation (Upper Cretaceous):

Shale; silty; grey. 25 +

Locality 5c: Elevation of bedrock---2110 feet \pm above
sea-level.
Lat. $53^{\circ} 34' 28''$ N., long. $113^{\circ} 19' 24''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; sandy; yellow-brown. 17

Saskatchewan gravels (Pleistocene):

Sand; yellow-brown; contorted upper contact
with till; frost action structures present
(deranged pebbles, ice-wedges), medium-
to very fine-grained; well-sorted;
subangular to subrounded; cross-bedded
(Pl. VI, Fig. 2). 6

Sand, with minor amounts of gravel;
cross-bedded; well-sorted; microfaulting
common; medium- to very fine-grained;
subrounded to well-rounded. 13 +

(a) Titanotylopus sp., distal articular
surface of a metapodial, UA 1622*,
greater than 20 feet below top of unit.

(b) Mammuthus cf. columbi Falconer,
partial LM₃, UA 1669*, greater than 20
feet below top of unit.

(c) Mammuthus cf. columbi Falconer,
partial molar, UA 1673*, greater than
20 feet below top of unit.

(d) ?Mammuthus sp., right scapula, TE
1670*, greater than 20 feet below top
of unit.

Bedrock not exposed.

* Specimens exposed by bulldozers.

Locality 6: Elevation of bedrock---2475 feet \pm above
sea-level.
Lat. $53^{\circ} 35' 25''$ N., long. $114^{\circ} 28' 13''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Till; clayey; grey; columnar. 4

Saskatchewan gravels (Pleistocene):

Gravel, with sand lenses up to 4" in
thickness; pebbles, 0.25"-3" long
diameter; subangular to well-rounded;
loosely cemented; well-sorted; matrix
of medium-to very fine-grained sand;
subrounded to well-rounded; loosely
cemented; well-sorted; pebbles com-
posed dominantly of brown quartzites,
with minor red arkosic sandstones,
clay ironstones, coal and bedrock
fragments. 15

(a) Equus cf. niobrarensis Hay, RP⁴,
UA 1634, 4 feet above base of unit.

Edmonton Formation (Upper Cretaceous):

Coal. 10+

Locality 7: Surface elevation---2150 feet \pm above sea-level.
 Lat. 54° 17' 45" N., long. 114° 50' 42" W.

	Thickness (feet)
Glacial Drift (Pleistocene):	
Till; grey.	4
Saskatchewan gravels (Pleistocene):	
Sand, with minor inclusions of gravel	14
Sand; silty; medium-grained.	1
Gravel, with minor amounts of sand; pebbles to boulders, 0.25"-14" long diameter; subrounded; poorly sorted; composed mainly of buff quartzites.	3
Sand; medium-grained.	1.5
Gravel, with minor amounts of sand.	4.5
Sand; coarse-to very fine-grained; oscillation ripple marks.	1.6
(a) <u>Equus</u> sp., distal end of a left tibia, DO 1655.	
Gravel and sand; poorly sorted.	1.3
Sand; fine-to medium-grained.	0.4+
Talus	33
Bedrock not exposed.	

Locality 8: Elevation of bedrock---1325 feet \pm above
sea-level.
Lat. $55^{\circ} 42' 59''$ N., long. $117^{\circ} 37' 51''$ W.

Thickness
(feet)

Glacial Drift (Pleistocene):

Gravel, sand, silt, and clay; interbedded;
minor amounts of till pods. 40 \pm

Stratified non-glacial sediments (Pleistocene):

Sand, silt, clay, peat; interbedded;
coarse- to medium-grained; rusty;
cross-bedded; angular to well-rounded;
molluscs; wood. 70 \pm

Saskatchewan gravels (Pleistocene):

Gravel, with minor amounts of sand; buff
to rusty-brown; pebbles imbricated at
085; pebbles to boulders, 0.25"-8" long
diameter; subrounded; poorly sorted;
loosely cemented; composed dominantly of
buff quartzites, with minor amounts of
sandstones, cherts, igneous rocks of
western provenance, clay ironstones, and
bedrock fragments near the base. 18

(a) Equus cf. niobrarensis Hay, left
lower jaw with P₄- M₁, UA 1637, 12 feet
above base of unit.

(b) Citellus sp., fragmentary right
edentulous mandible, UA 1662, 12 feet
above base of unit.

Dunvegan Formation (Lower Cretaceous):

Shale; weathered; rusty-brown. 2 +

APPENDIX B:

TABLES OF MEASUREMENTS OF SKELETAL ELEMENTS OF
VERTEBRATES FROM THE SASKATCHEWAN GRAVELS

Table 1. Citellus sp. Comparative dimensions of right
lower jaws of Pleistocene and Recent species. Measure-
ments in parentheses are approximate.

DIMENSIONS (in mm)	UA 1662	UAMZ 4473*	UAMZ 436*	UAMZ 3119*	UAMZ 1517*
Alveolar length, P ₄ -M ₁ ..	13.0	11.0	11.0	10.5	11.0
Depth at M ₃ , lingual side	7.0	7.0	6.7	8.5	6.6
Depth at P ₄ , labial side	6.4	7.0	6.0	7.5	6.5
Length, mandibular to mental foramen	(20.5)	17.0	15.5	17.8	16.0
Length, diastema	7.0	8.6	5.5	8.6	7.0

*4473; C. franklini (Recent)

*436 ; C. lateralis (Recent)

*3119; C. columbians (Recent)

*1517; C. richardsoni (Recent)

Table 2. Titanotylopus sp. Dimensions of distal articular surface of metapodial (UA 1622).

DIMENSIONS (in mm)	UA 1622
Width, distal articular surface	61.0
Length, distal articular surface	51.0

Table 3. Camelops sp. Dimensions of partial ?RM₃, (UA 1623).

DIMENSIONS (in mm)	UA 1623
Occlusal width	17.0
Height, crown	84.0

Table 4. Camelops sp. Dimensions of right P_4 (UA 1624).

DIMENSIONS (in mm)	UA 1624
Occlusal length	28.0
Occlusal width	15.0
Height, crown	39.0

Table 5. Camelops sp. Dimensions of distal articular surface of metapodial (UA 1626).

DIMENSIONS (in mm)	UA 1626	
Width, distal articular surfaces	39.0	38.0
Anteroposterior length, distal articular surfaces	37.5	38.0

Table 6. Antilocapra sp. Comparative dimensions of upper premolars of UA 1661 and Recent species.

DIMENSIONS (in mm)		UA 1661	UAMZ 3226*
P ₂ ,	Occlusal length	7.6	7.5
	Occlusal width	4.9	5.2
	Height, crown	16.6	18.4
P ₃ ,	Occlusal length	11.5	10.4
	Occlusal width	7.2	7.6
	Height, crown	24.4	23.3

*3226; Antilocapra americana Ord (Recent)

Table 7. Bison sp. Comparative dimensions of thoracic vertebrae
of Bison occidentalis Lucas (DDMS Ta-B-14-15-16) and UA 932.

DIMENSIONS (in mm)	UA 932 5th	TAB 14 4th	TAB 15 5th	TAB 16 6th
Length, centrum through centers of epiphyses	69.0	69.0	71.0	71.0
Width, across prezygapophyses	37.0	36.0	41.0	43.0
Width, across anterior costal demifacets	54.0	62.0	61.0	62.0
Height, centrum, anterior central epiphyses	54.0	55.0	53.0	54.0
Height, anterior opening neural canal	24.0	25.0	24.0	24.0
Width, across postzygapophyses	38.0	36.0	36.0	39.0
Height, posterior opening neural canal	25.0	30.0	28.0	27.0
Width, across posterior costal demifacets	83.0	86.0	90.0	94.0
Height, centrum, posterior central epiphyses	57.0	56.0	57.0	58.0
Height, ventral ridge to top of postzygapophyses	97.0	94.0	97.0	97.0
Length, posterior part of prezygapophyses to posterior part of postzygapophyses	76.0	73.0	77.0	80.0
Greatest width, spine, normal to last measurement	36.0	34.0	34.0	35.0

Table 8. Equus cf. niobrarensis Hay. Comparative dimensions of upper incisors of Pleistocene species.

DIMENSIONS (in mm)		USNM 4999*	USNM 7700*	Equus cf. niobrarensis	
				UA 1638	UA 1639
RI ³ ,	Occlusal length	22.0	24.0	22.0	
	Occlusal width	9.0	10.5	11.0	
RI ² ,	Occlusal length	17.5	18.5	16.0	
	Occlusal width	10.0	12.0	12.5	
RI ¹ ,	Occlusal length	18.5	19.5	15.0	
	Occlusal width	11.0	13.0	13.0	
LI ¹ ,	Occlusal length.....	18.0	18.0	16.0	16.5
	Occlusal width	11.0	11.0	12.5	
LI ² ,	Occlusal length	20.5	20.0		
	Occlusal width	10.5	11.5		
LI ³ ,	Occlusal length		24.5		
	Occlusal width	9.0	11.0		
RI ³ , cup,	Occlusal length ...		14.5	13.5	
	Occlusal width		6.0	5.0	
	Depth	20.0		20.0	
RI ² , cup,	Occlusal length ...	11.0	15.0	12.5	
	Occlusal width	4.0	6.0	5.5	
	Depth	20.0		20.0	
RI ¹ , cup,	Occlusal length ...	9.0	13.5	11.5	
	Occlusal width	4.0	4.5	5.0	
	Depth			12.0	
LI ¹ , cup,	Occlusal length ...	11.0	13.5	11.0	
	Occlusal width	5.0	4.5	5.0	
	Depth			12.0	20.0
LI ² , cup,	Occlusal length ...	11.0	14.5		
	Occlusal width	4.0	5.5		
	Depth	20.0			
LI ³ , cup,	Occlusal length ...		15.5		
	Occlusal width	6.0	6.0		
	Depth	20.0			

USNM 4999* E. niobrarensis

USNM 7700* E. n. alaskae

Table 9. Equus cf. niobrarensis Hay. Comparative dimensions of upper teeth of Pleistocene species.

DIMENSIONS (in mm)	USNM 4999*	USNM 7700*	MMP 46898*	<u>Equus</u> cf. <u>niobrarensis</u>						UA 1631	UA 1632	UA 1633
				UA 1627	UA 1628	UA 1629	UA 1630	UA 1631	UA 1632			
P ² , Occlusal length	38.0	38.5	41.6	40.0	40.5	40.0	41.5					
Occlusal width	27.0	26.5	27.5	26.5	28.5	29.0	30.0	27.0				
Length, protocone ...	9.5	9.5	11.0	10.0	9.0	10.5	11.0	11.0				
P ³ , Occlusal length	31.0	28.5	31.0									
Occlusal width	28.0	28.5	29.0									
Length, protocone ...	13.5	12.5	15.0									
P ⁴ , Occlusal length	30.0	28.0	31.5									
Occlusal width	26.0	28.0	31.5									
Length, protocone ...	13.5	14.5	16.0									

USNM 4999* E. niobrarensis

USNM 7700* E. n. alaskae

MMP 46898* E. scotti

Table 9. (cont'd) Equus cf. niobrarensis Hay. Comparative dimensions of upper teeth of Pleistocene species.

DIMENSIONS (in mm)	USNM 4999*	USNM 7700*	MMP 46898*	Equus cf. niobrarensis						
				UA 1627	UA 1628	UA 1629	UA 1630	UA 1631	UA 1632	UA 1633
M ¹ , Occlusal length	27.5	24.5	28.0		29.5				28.0	
Occlusal width	27.5	26.5	28.5		26.5				20.5	
Length, protocone ...	13.0	11.5	14.0		13.0				12.5	
M ² , Occlusal length	28.0	25.8	30.0		29.0					29.0
Occlusal width	25.0	25.5	31.0		24.5					27.0
Length, protocone ...	13.5	12.0	15.5		13.5					14.5
M ³ , Occlusal length	26.0	26.5	29.0		27.0					
Occlusal width	22.5	24.0	26.0		17.0					
Length, protocone ...	14.0	12.5	16.5							

USNM 4999* E. niobrarensis
 USNM 7700* E. n. alaskae
 MMP 46898* E. scotti

Table 10. Equus cf. niobrarensis Hay. Dimensions of left lower jaw (UA 1637).

DIMENSIONS (in mm)	UA 1637
Occlusal length, P ₂ - P ₄	103.4
Depth, normal to P ₄	70.0
Depth, normal to mental foramen	36.4
Length, posterior part of mental foramen to anterior part P ₂	24.0
Height, crown P ₂	37.5
P ₃	40.5
P ₄	51.0

Table 11. Equus cf. niobrarensis Hay. Comparative dimensions of lower teeth of Pleistocene species. Dimensions in parentheses are approximate.

DIMENSIONS (in mm)		<u>Equus</u> <u>scotti</u>	<u>Equus</u> <u>niobrarensis</u>	<u>Equus</u> cf. <u>niobrarensis</u>		
		MMP 46898	USNM 4999	1636	1637	1634
P ₂ ,	Occlusal length	40.0	35.0		30.0	
	Occlusal width	16.0	16.0		13.0	
P ₃ ,	Occlusal length	34.5	28.5		32.0	
	Occlusal width	19.0	18.0		13.0	
P ₄ ,	Occlusal length	31.5	30.0		(31.0)	29.4
	Occlusal width	20.0	16.0		(12.0)	17.0
M ₁ ,	Occlusal length	29.5	27.5	(28.0)		
	Occlusal width	18.0	15.0	13.0	(12.0)	
M ₂ ,	Occlusal length	31.5	27.0			
	Occlusal width	16.0	13.5			
M ₃ ,	Occlusal length	40.5	30.5			
	Occlusal width	16.0	12.5			

Table 12. Equus sp. Dimensions of left scapula (UA 1658).

DIMENSIONS (in mm)	UA 1658
Width, distal extremity.....	48.0
Anteroposterior length, distal extremity.....	96.4
Length, glenoid cavity	57.3
Width, glenoid cavity	46.2

Table 13. Equus sp. Dimensions of third metapodials (UA 1643, UA 1644, UA 1645, and P 1646), after Willoughby (1948).

DIMENSIONS (in mm)	meta- carpal UA 1643	meta- carpal UA 1644	meta- carpal UA 1645	meta- tarsal P 1646
Maximum length	250.0	249.0	217.0	
Articular length*	240.0	240.0	210.0	
Maximum width, proximally..	50.0	56.0	46.0	50.0
Maximum anteroposterior depth, proximal extremity .	35.0	38.0	31.0	43.0
Maximum width, shaft	35.0	37.0	30.0	35.0
Minimum anteroposterior depth, shaft	27.0	30.0	23.0	32.0
Maximum width, distal articulation	47.0	52.0	44.0	
Maximum anteroposterior depth, distal extremity....	39.0	40.5	39.0	

* From the lateral edge of the facet adjoining the fourth carpal bone to the lateral distal edge of the trochlea, in line with the long axis of the shaft.

Table 14. Equus sp. Dimensions of first phalanges (UA 1659, UA 1660, and UA 1661).

DIMENSIONS (in mm)	UA 1659	UA 1660	UA 1661
Maximum length	85.7	86.5	89.5
Length, between centers of articulating facets	76.3	80.0	79.7
Anteroposterior length, proximal extremity	38.0	40.0	38.0
Width, proximal extremity	54.6	52.8	55.8
Anteroposterior length, distal extremity	23.8	29.3	26.2
Anteroposterior length, medial part of shaft	26.4	26.4 26.4	27.5 27.5
Transverse width, medial part of shaft	35.4	32.6	36.6
Width, distal extremity	44.6	40.4	47.3

Table 15. Equus sp. Dimensions of second phalanges (UA 1644 and UA 1663).

DIMENSIONS (in mm)	UA 1644	UA 1663
Maximum length	45.6	46.6
Length, between centers of articulating facets	44.0	43.2
Anteroposterior length, proximal extremity	31.3	34.8
Width, proximal extremity	53.4	54.9
Anteroposterior length, distal extremity	31.7	28.9
Anteroposterior length, medial part of shaft	23.9	25.7
Transverse width, medial part of shaft	46.4	44.6
Width, distal extremity	50.3	47.2

Table 16. Equus sp. Dimensions of left innominates (UA 1665 and UA 1666). Dimension in parenthesis is approximate.

DIMENSIONS (in mm)	UA 1665	UA 1666
Greatest length, acetabulum	58.0	71.2
Depth acetabulum	28.9	35.3
Length, dorsal rim of acetabulum to ischiatic spine	(42.3)	60.2
Greatest dorsoventral length, iliac shaft	37.5	47.3
Width, shaft (at same point)	21.2	30.6
Greatest dorsoventral length, acetabular shaft	23.6	38.2
Width, shaft (at same point)	21.5	30.0
Greatest anteroposterior length, symphyseal shaft	24.6	37.1
Width, shaft (at same point)	16.4	22.3

Table 17. Equus sp. Dimensions of femora (UA 1640 and UA 1641).

DIMENSIONS (in mm)	left UA 1640	right UA 1641
Maximum length	414.0	406.0
Length, head to intercondyloid fossa	358.0	349.0
Width, proximal extremity	117.0	116.0
Anteroposterior length, head	61.0	62.0
Least width, shaft	46.0	46.0
Least anteroposterior length, shaft	50.0	50.0
Posterior width, across lateral and medial epicondyles	98.0	100.0
Anteroposterior length, distal extremity: medial lateral	121.0 94.0	118.0 96.0
Width, across anterior part of trochlea ...	62.0	
Depth, supracondyloid fossa to anterior part of shaft	20.0	22.0
Anteroposterior length, intercondyloid fossa to anterior part of shaft	53.0	53.0

Table 18. Equus sp. Dimensions of left tibiae (DO 1655 and UA 1656).

DIMENSIONS (in mm)	DO 1655	UA 1656
Width, proximal extremity		102.5
Anteroposterior length, proximal extremity ...		83.0
Width, distal extremity	69.0	
Anteroposterior length, distal extremity	42.5	
Least width, shaft	42.0	47.0
Least anteroposterior length, shaft	38.4	45.5

Table 19. Equus sp. Dimensions of left fibular tarsals (UA 1647 and UA 1648). Dimension in parenthesis is approximate.

DIMENSIONS (in mm)	UA 1647	UA 1648
Maximum length	113.0	(91.5)
Anteroposterior length, medial side ..	47.3	49.2
Maximum width, medial side	46.4	45.2

Table 20. Equus sp. Dimensions of partial left tibial tarsal (UA 1649).

DIMENSIONS (in mm)	UA 1649
Maximum anteroposterior length	63.8
Anteroposterior length, trochlear groove to distal surface	50.0
Length, ventral facet	41.0
Width, ventral facet	26.0

Table 21. Mammuthus cf. columbi Falconer. Dimensions of molars (UA 1669, UA 1672, UA 1673, and UA 1674).

Dimensions in parentheses are approximate.

DIMENSIONS (in mm)	<u>M. cf.</u> <u>columbi</u>		<u>Mammuthus</u> sp.	
	UA 1669	UA 1673	UA 1672	UA 1674
Maximum anteroposterior length ...	80.0	(66.5)		
Occlusal length	80.0	62.0		
Occlusal width	91.0	80.5	84.0	(73.0)
Maximum thickness, enamel of the plate	4.0	4.5	3.5	3.0
Minimum thickness, enamel of the plate	2.5	2.0	2.6	1.5
Maximum anteroposterior length, plate	17.0	14.0	12.0	11.0
Minimum anteroposterior length, plate	8.5	9.0	(7.0)	(8.0)
Height, crown	121.0	69.5		
Number ridge plates per 50.0 mm measured on midline of crown..worn	2.5	3.0	3.0	
	unworn	4.5		
Number ridge plates per 50.0 mm measured medially and laterally:				
	labial	3.0	(4.0)	
	lingual	3.0		

Table 22. ?Mammuthus sp. Dimensions of right scapula
(TE 1670). Dimensions in parentheses are approximate.

DIMENSIONS (in mm)	TE 1670
Maximum length	(666.0)
Width, glenoid cavity	98.0
Anteroposterior length, distal extremity	257.0
Anteroposterior length, glenoid cavity	221.0
Maximum anteroposterior length, proximal extremity	(260.0)
Depth, glenoid cavity	(39.0)

Table 23. ?Mammuthus sp. Dimensions of partial tusks (UA
1667 and UA 1668). Dimensions in parentheses are
approximate.

DIMENSIONS (in mm)	UA 1667	UA 1668
Maximum length	(545.0)	(260.0)
Maximum thickness	98.0	74.0

PLATE I

- Fig. 1. UA 1662. Citellus sp., occlusal view of right mandible.
- Fig. 2. UA 1662. Citellus sp., external view.
- Fig. 3. UA 1662. Citellus sp., internal view.
- Fig. 4. UA 1624. Camelops sp., occlusal view of right P₄.
- Fig. 5. UA 1626. Camelops sp., ventral view of metapodial.
- Fig. 6. UA 1622. Titanotylopus sp., anterior view of partial metapodial.
- Fig. 7. UA 1623. Camelops sp., external view of partial ?right M₃.
- Fig. 8. UA 1623. Camelops sp., occlusal view.

PLATE I



PLATE II

- Fig. 1. UA 1661. Antilocapra sp., external view of right maxillary fragment.
- Fig. 2. UA 1661. Antilocapra sp., internal view.
- Fig. 3. UA 1638. Equus cf. niobrarensis, internal view of upper incisors.
- Fig. 4. UA 932. Bison sp., posterior view of 5th thoracic vertebra.
- Fig. 5. UA 932. Bison sp., lateral view.
- Fig. 6. UA 1631. Equus cf. niobrarensis, occlusal view of left P².
- Fig. 7. UA 1630. Equus cf. niobrarensis, occlusal view of right P².

PLATE II

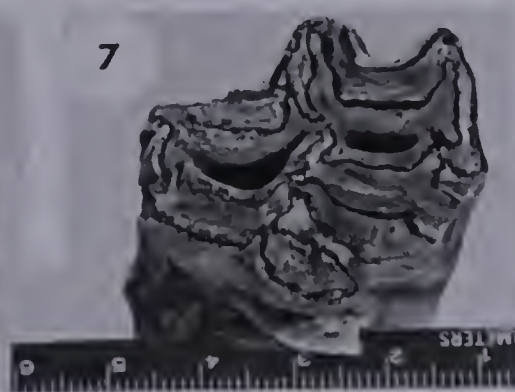
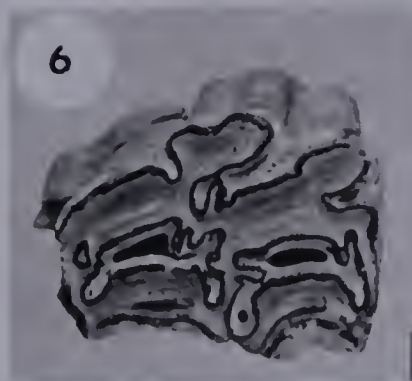
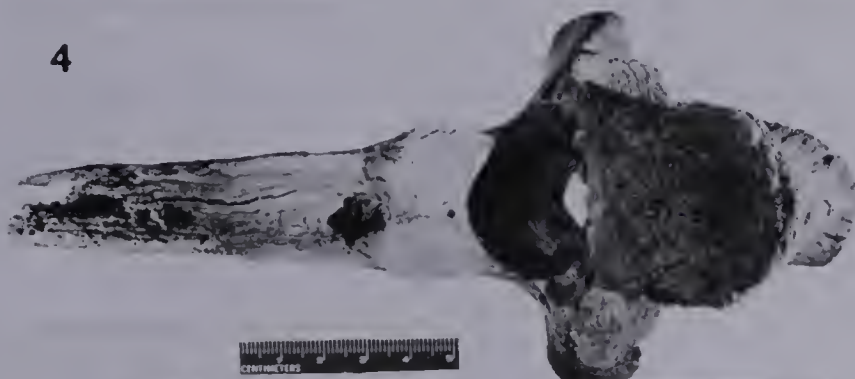
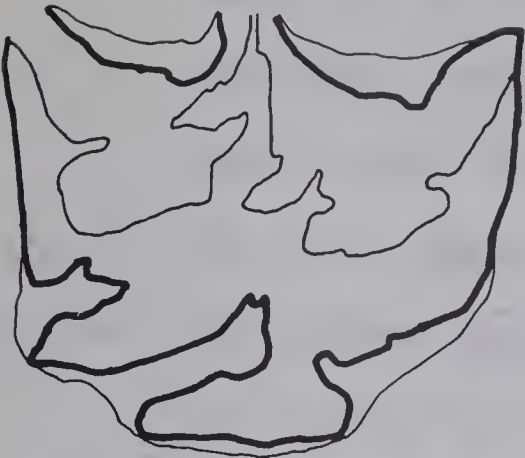


PLATE III

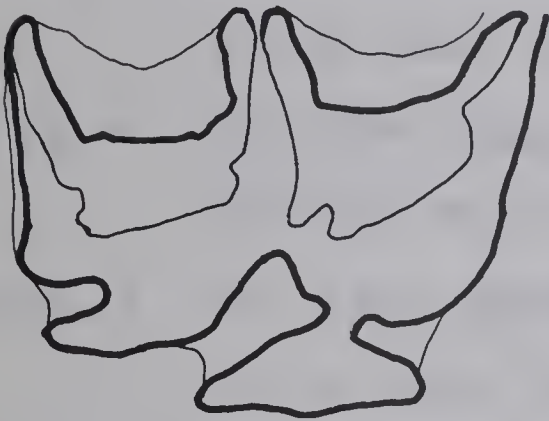
- Fig. 1. UA 1632a. Equus cf. niobrarensis, occlusal view of right M^1 , at crown, X 4.
- Fig. 2. UA 1632b. Equus cf. niobrarensis, occlusal view 27 mm below the crown, X 4.
- Fig. 3. UA 1633a. Equus cf. niobrarensis, occlusal view of right M^1 , at crown, X 4.
- Fig. 4. UA 1633b. Equus cf. niobrarensis, occlusal view 15 mm below the crown, X 4.
- Fig. 5. UA 1633c. Equus cf. niobrarensis, occlusal view 33 mm below the crown.

PLATE III

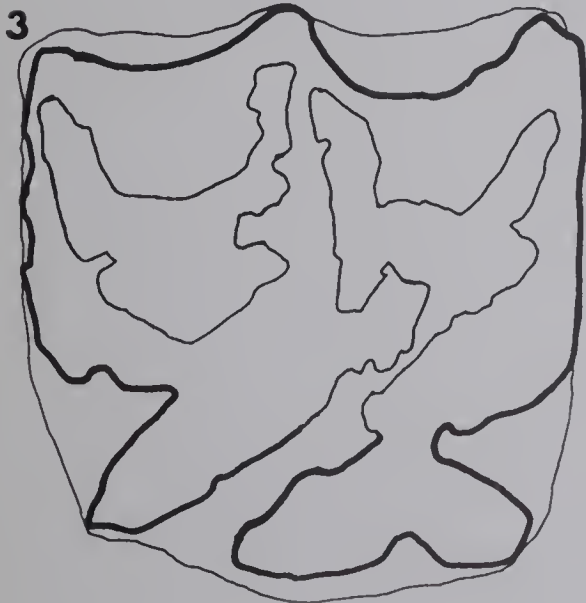
1 UA1632a



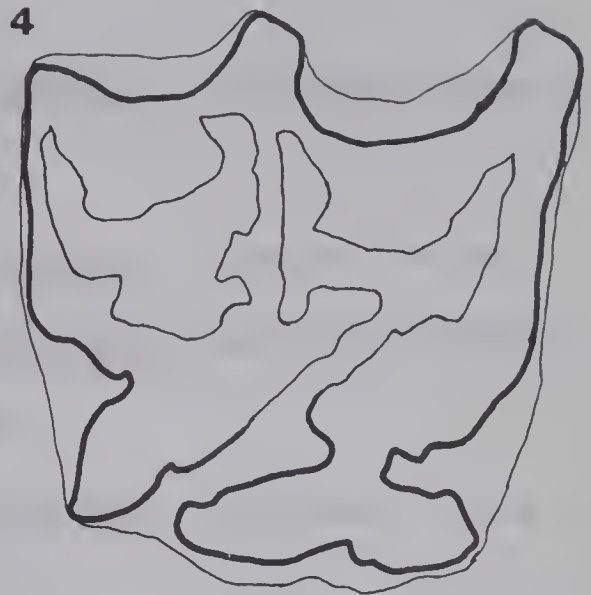
2 UA1632b



UA1633a



UA1633b



UA1633c

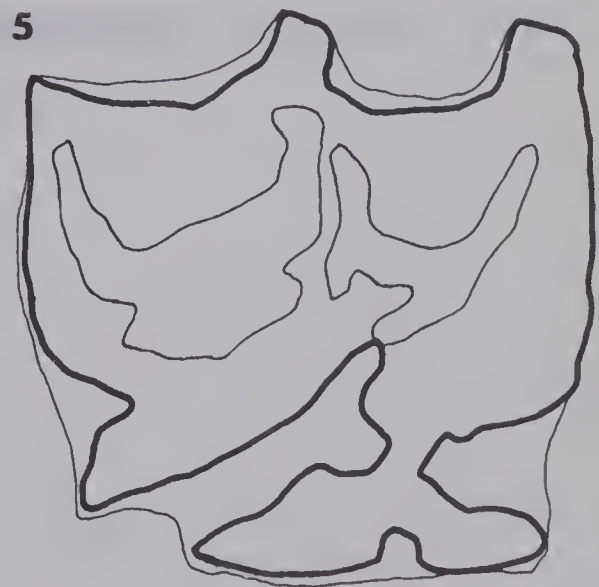
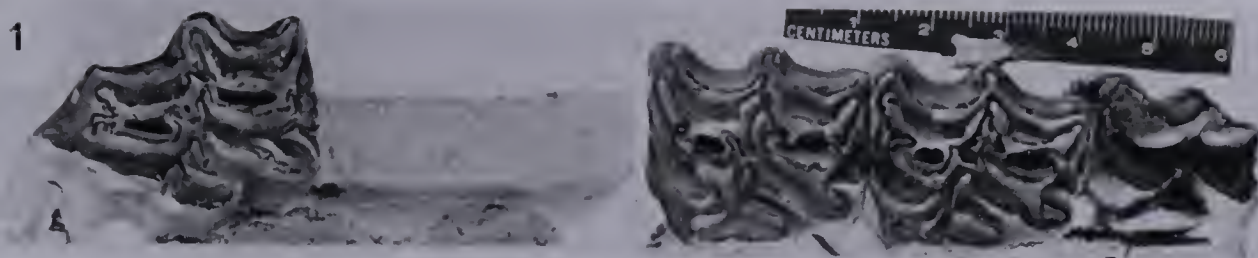


PLATE IV

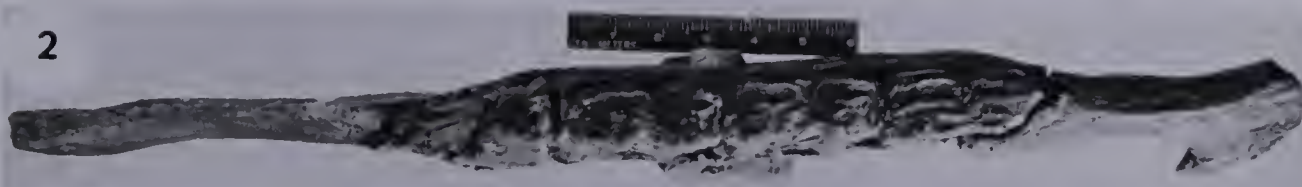
- Fig. 1. UA 1628. Equus cf. niobrarensis, occlusal view of left P^2 , M^1 - M^3 .
- Fig. 2. UA 1637. Equus cf. niobrarensis, occlusal view of left lower jaw with P_4 - M_1 .
- Fig. 3. UA 1637. Equus cf. niobrarensis, internal view.
- Fig. 4. UA 1634a. Equus cf. niobrarensis, occlusal view of right P_4 , at crown, X 4.
- Fig. 5. UA 1634b. Equus cf. niobrarensis, occlusal view 15 mm below the crown, X 4.
- Fig. 6. UA 1636a. Equus cf. niobrarensis, occlusal view of right M_1 , at crown, X 4.
- Fig. 7. UA 1636b. Equus cf. niobrarensis, occlusal view 15 mm below the crown, X 4.

PLATE IV

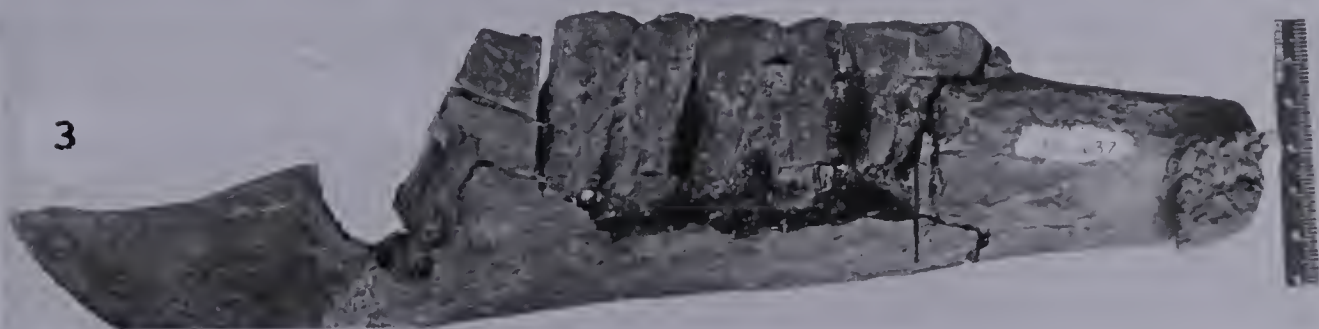
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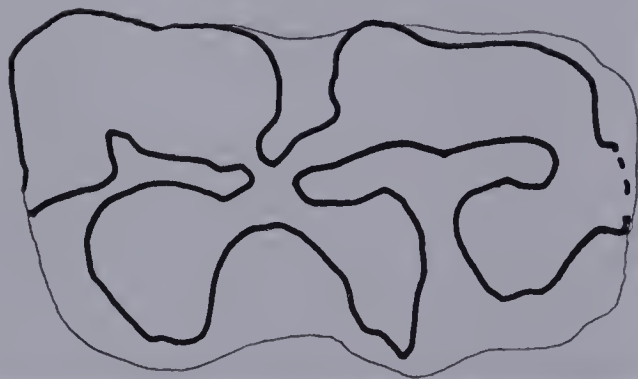


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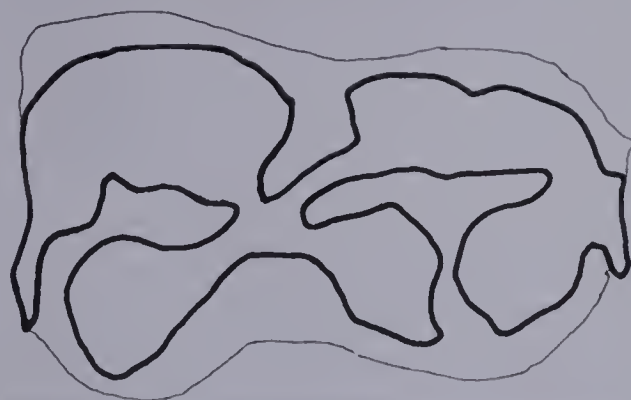
4

UA1634a



5

UA 1634b



6

UA 1636a



7

UA 1636b

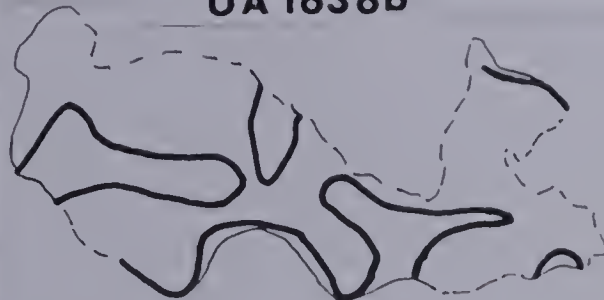


PLATE V

- Fig. 1. UA 1644. Equus sp., anterior view of partial limb and foot.
- Fig. 2. UA 1641. Equus sp., posterior view of right femur.
- Fig. 3. UA 1669. Mammuthus cf. columbi, external view of partial left lower molar.
- Fig. 4. UA 1673. Mammuthus cf. columbi, occlusal view of partial molar.
- Fig. 5. UA 1669. Mammuthus cf. columbi, occlusal view.

PLATE V

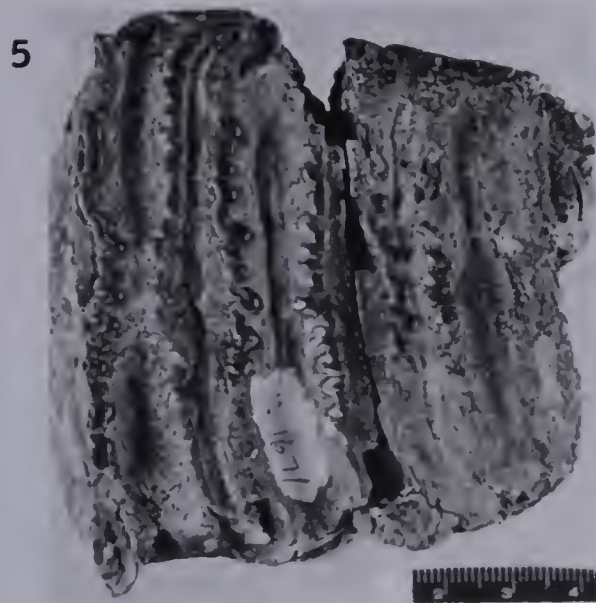
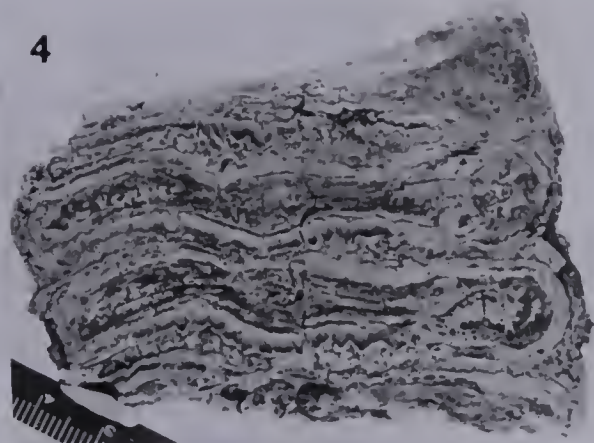
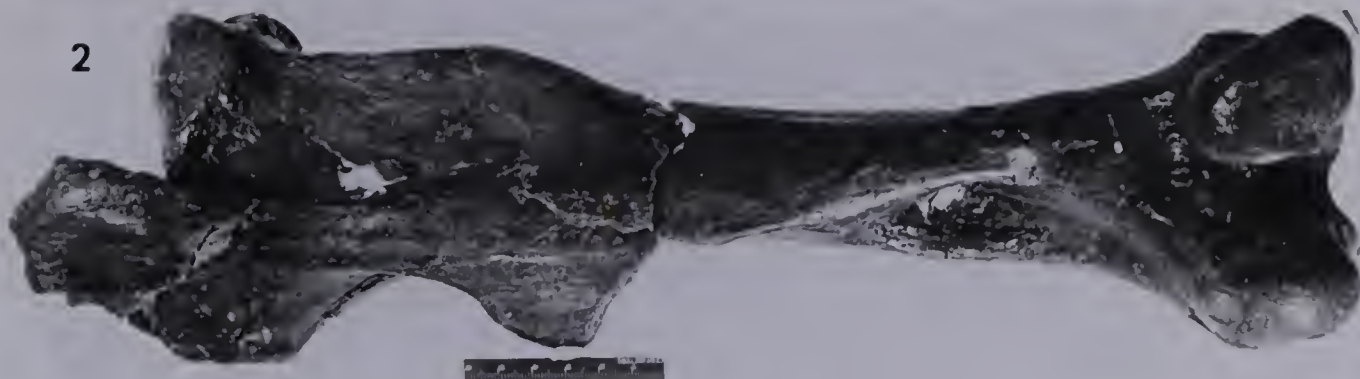


PLATE VI

- Fig. 1. UA 1628. Equus cf. niobrarensis, in situ, twenty-five cent piece for scale.
- Fig. 2. View of Loc. 5c showing periglacial structures in Saskatchewan gravels and overlying glacial drift in background.

PLATE VI



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